

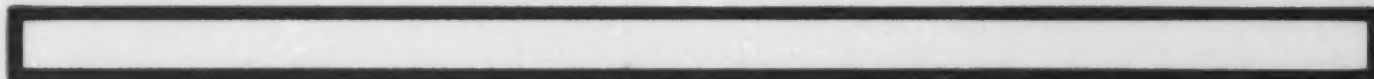
EPA (Environmental Protection Agency)
Guide for Minimizing the Adverse
Environmental Effects of Cleanup of
Uncontrolled Hazardous-Waste Sites

Battelle Pacific Northwest Labs., Richland, WA

Prepared for

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DISCLAIMER

This manual describes scientifically relevant and important functional activities that concern regional, state, and local authorities during the response to hazardous substance releases. It is intended to convey technical recommendations only and not to constitute agency policy. The manual should not supersede specific procedures and documentation for quality assurance, chain-of-custody, and other requirements addressed by Environmental Protection Agency regulations and policy guidance documents currently in effect. The research described in this report has been funded by the United States Environmental Protection Agency through interagency agreement no. AD-89-F-2A115 to the United States Department of Energy. This report has been subjected to the Agency's required peer and policy review.

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**EPA GUIDE FOR
MINIMIZING THE ADVERSE ENVIRONMENTAL EFFECTS OF
CLEANUP OF UNCONTROLLED HAZARDOUS-WASTE SITES**

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AD-89-F-2A115

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PREFACE

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) grants the President the authority to respond to releases of hazardous chemical substances that imminently and substantially threaten public health or welfare, or the environment. The Act, which establishes a \$1.6-billion Superfund to finance response action, and which charges the Environmental Protection Agency (EPA) with administering critical portions of the response program, was designed to build on the existing environmental response authority given to EPA under Section 311 of the Clean Water Act.

In accordance with this mandate, the EPA is preparing a series of documents to assist state and regional officials who are responsible for instituting cleanup actions at specific hazardous-waste sites. This guide deals exclusively with environmental effects of remedial actions.

This guide supplies information and sources that an official needs to evaluate how to proceed at a contaminated site. This document also can be used by management to assist in and overview staff cleanup activities. Additionally, it is a training tool for persons who are new to the business of cleaning up hazardous-waste sites. Finally, it is a resource for anyone who wishes to know more about the cleanup of hazardous-waste sites.

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1.0 PURPOSE OF THIS GUIDE

This document is intended to guide on-site decision authorities in appraising and analyzing potential environmental consequences of any given alternative for cleanup of an uncontrolled hazardous-waste site. As such, this guide focuses on the "Analysis of Alternatives" step of the cleanup process (Figure 1.1).

The Environmental Protection Agency (EPA) has published a "Handbook for Remedial Action at Waste Disposal Sites" (EPA 625/6-82-006, June 1982), henceforth referred to as EPA 1982. That manual presents information on technologies which may be applicable to specific problems of controlling hazardous wastes at disposal sites. EPA 1982 is a comprehensive treatise on the many corrective practices used to clean up hazardous-waste sites and spills. EPA 1982 provides technical assistance to Federal, state, and local agencies in identifying and analyzing cleanup alternatives; it does not, however, cover any technology exhaustively, nor does it cover all topics that must be considered in analyzing alternative cleanup actions.

A critical factor in the analysis of treatment options is the cost-effectiveness of the various alternatives. An important element in the cost-effectiveness evaluation is consideration of the consequences of the various treatment options because negative secondary effects often may result from well-intentioned and conducted treatment measures.

This guide is structured to be used in conjunction with EPA 1982. The treatment options described in EPA 1982 that may be used as components of a cleanup strategy are summarized here in terms of their potentially adverse environmental effects. To the extent that specific information is available, that information is presented and documented. In cases where specific information is not available (i.e., where current knowledge is sparse, unconfirmed, or lacking), a subjective appraisal, with appropriate qualification, is included. The remedial actions are discussed only in sufficient detail to identify what adverse effects each may cause. EPA 1982 describes the remedial actions more fully.

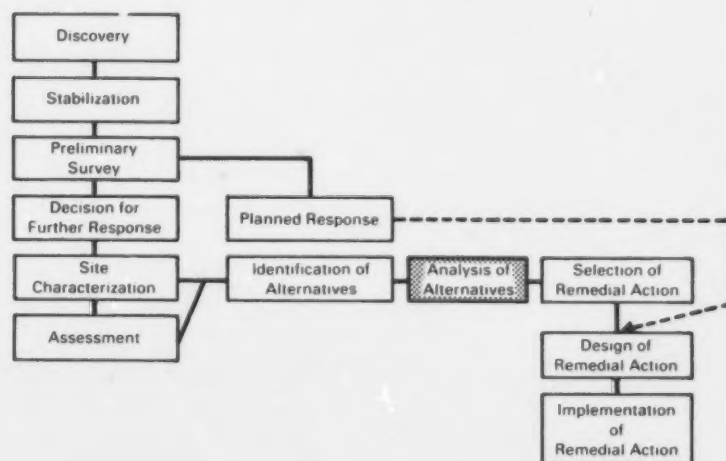


FIGURE 1.1 Steps in the Cleanup Process

2.0 HOW TO USE THIS GUIDE

Before a decision maker uses this guide, he/she should have identified a preliminary list of remedial actions (during the "Identification of Alternatives" step shown in Figure 1.1). These alternatives will have been chosen for their potential to meet cleanup criteria at the site, taking into account the specific characteristics of the site.

The basis for and principles of each of the potential technologies are discussed in EPA 1982. Also discussed in that document is the basis for estimating the cost of each alternative. Because this companion document will be used in conjunction with EPA 1982, those considerations are not reiterated here.

This guide provides information on the potential adverse environmental effects associated with each alternative. It addresses qualitatively the projected significance or probability of the effect, the extent to which it may be avoided or mitigated, its persistence (during the construction phase only or persisting into the indefinite future), and whether the effect is related to hazardous matter or unrelated to the presence of hazardous material (a nuisance effect). Because any adverse effects will be controlled by site-specific factors, the discussion here is generic. It is intended to stimulate consideration of each of the possible effects; it is not intended to be all inclusive.

The organization of this guide parallels that of EPA 1982. That is, in EPA 1982, technical aspects of surface sealing are discussed in Section 3.1; in this guide, environmental aspects of surface sealing are likewise discussed in Section 3.1. Thus, the sections of EPA 1982 correspond on a one-to-one basis with those here. This document has two additional sections, Addendum 1 and Addendum 2, which do not correspond to any sections in EPA 1982. Since EPA 1982 has appendices (with corresponding appendices in this document), the supporting sections here have been called addenda.

Summary tables are provided for each technology to describe potential environmental effects to ground-water quantity/movement, ground-water quality, surface-water quantity/movement, surface-water quality, air quality, soils/geology, biota, human health and safety, and resource commitment. Each table is designed to give the reader a quick reference to estimate the level of concern about the effect to each medium as reflected by a subjective probability for its occurrence (from "highly probable" to "no effect predicted"); the duration of the effect (short term—lasting only during the remedial activity—or long term—persisting beyond the period of the activity); the extent to which it is reversible, preventable, or mitigable; and whether the effect is related to the hazardous matter at the site or whether it is an impact that would occur on any site on which the activity is performed.

For each specific activity, good engineering practice (GEP) tables are provided and referenced at the end of each section. These GEP tables provide a brief description of the nature of the potential adverse environmental effect associated with that activity and a brief description of the mitigative action that may be taken to prevent, correct, or minimize each effect.

The text accompanying each table contains a more complete discussion of the potential effects, a description of mitigation or avoidance measures, and, where applicable, their costs (information is incorporated by reference where possible). Because this guide is a companion to EPA 1982, each section is intended to support the corresponding section of EPA 1982. As a result there is considerable repetition from section to section of this guide.

3.0 SURFACE CONTROLS

Surface controls are measures undertaken to prevent surface waters and wind from causing off-site transport of hazardous matter. The methods discussed are surface sealing (capping), grading, revegetation, and surface-water diversion and collection.

3.1 SURFACE SEALING

Surface sealing (or capping) is a method for covering hazardous-waste disposal sites to prevent surface-water infiltration, control wind and water erosion, and prevent the migration to the surface of contaminants, waste, or volatile matter (EPA 1982). Capping contaminated surface soil will also reduce the release of materials into the atmosphere. Various weather elements can act to enhance release rates. Particulate releases increase during high winds and during rainfall. Gaseous releases can be increased depending on surface temperature, moisture, and as the result of changes in atmospheric pressure. Depending on the contaminant composition, the capping measure will reduce atmospheric releases of dust and vapor. The potential effects associated with the use of surface-sealing measures are summarized in Table 3.1 and described in the good engineering practice tables, Tables 3.1a-j, at the end of this section.

Because the areas covered by uncontrolled hazardous-waste sites are generally small compared to the total recharge zone for near-surface aquifers, surface sealing is not expected to significantly affect ground-water quantity and/or ground-water movement. Likewise, because capping is intended to prevent infiltration, it is not projected to negatively affect ground-water quality. (The overwhelming effect should be positive because it reduces transport of the hazardous material into the aquifer.) If, however, industrial residues that contain toxic or objectionable materials are used for capping, ground-water quality could be negatively affected. Fly ash, bottom ash and slag, furnace slag, and incinerator residue all contain heavy metals and other objectionable materials. Dredge materials often contain significant quantities of toxic and other objectionable materials. Nontoxic industrial sludges and composted sewage sludge may contain significant quantities of objectionable materials (such as nitrates, in the case of sewage sludge). If the cover materials contain objectionable or toxic materials and if these materials can find their way into the ground water, they can degrade ground-water quality. Additionally, the use of industrial residues as capping material may cause increased release of toxic contaminants; reaction of chemicals in water that has passed through the industrial residue with the hazardous waste may mobilize the waste. These potential effects of the use of industrial residues can be minimized by careful selection and testing of candidate capping materials.

Capping of a facility and diverting run-on and runoff waters may affect ground water if insufficient care is taken in disposing of the waters. Lateral movement of infiltrating ground water must be considered in the design of capping activities (Figure 3.1). Protection of the facility must be carried out to some distance from the waste-storage area to prevent any infiltration of diverted waters into the waste area.

If surface sealing functions as designed, it will affect surface-water movement by diverting waters (that would otherwise infiltrate) off site. In turn, this increased runoff to off-site locations could potentially cause off-site erosion and degrade water quality by carrying soil to surface-water bodies. If off-site erosion occurs, it could remove habitat for terrestrial biota. If surface-water quality is degraded as a result of off-site erosion, aquatic habitat will be degraded. Additionally, if the short-term runoff results in silting of the receiving waters, a short-term impact on biota in receiving waters can be expected. A small amount of silt can have a significant effect on the aquatic ecosystem if fish spawning or insect reproduction cycles are affected. Each of these possible negative effects may be avoided by managing the runoff through appropriate grading and/or off-site surface-water controls. Off-site surface-water controls may include diversion ditches or infiltration basins used in conjunction with revegetation. Design and cost considerations for these are discussed in EPA 1982 (Sections 3.3 and 3.4).

TABLE 3.1. Effects of Surface Controls: Surface Sealing (Capping)

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Soil Blending	⊙ HPR	—	⊙ NPR	● NPR	● NSR ⊙ HPR	⊙ NPR	⊙ HPR ⊙ NPR	⊙ HPR	—
Blending in Cements/ Stabilizers	⊙ HPR	—	⊙ NPR	● NPR	● NSR ⊙ HPR	⊙ NPR	⊙ HPR ⊙ NPR	⊙ HPR	—
Soil Treating									
• lime/fly ash	⊙ HPR	—	⊙ NPR	● NPR	● NSR ⊙ HPR	⊙ NPR	⊙ HPR ⊙ NPR	⊙ HPR	—
• chemical dispersants/ swell reducer	⊙ HPR	—	⊙ NPR	● NPR	● NPR ⊙ HPR	⊙ NPR	⊙ HPR ⊙ NPR	⊙ HPR	—
Clay Capping	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
Portland Cement, Concrete, or Mortar	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
Bituminous Concrete Covering	⊙ HPR	—	⊙ NPR	● NPR	● NSI ● NSR	⊙ NPR	⊙ NPR	—	—
Bituminous Membrane Covering	⊙ HPR	—	⊙ NPR	● NPR	● NSI ● NSR	⊙ NPR	⊙ NPR	—	—
Sprayed Sulfur/ Polyurethane Membranes	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
Poly (VC, Chlor. E., etc.) Covers	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—

● = Highly Probable

⊙ = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

R = Reversible (or mitigable)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

TABLE 3.1. (Continued)

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Industrial Residues									
• fly ash	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• bottom ash/ slag	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• furnace slag/ incinerator residue	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• mine overburden	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• dredge material	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• industrial sludges (nontoxic)	⊙ HPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—
• compacted sewage sludge	⊙ HPR ⊙ NPR	—	⊙ NPR	● NPR	● NSR	⊙ NPR	⊙ NPR	—	—

● = Highly Probable

⊙ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

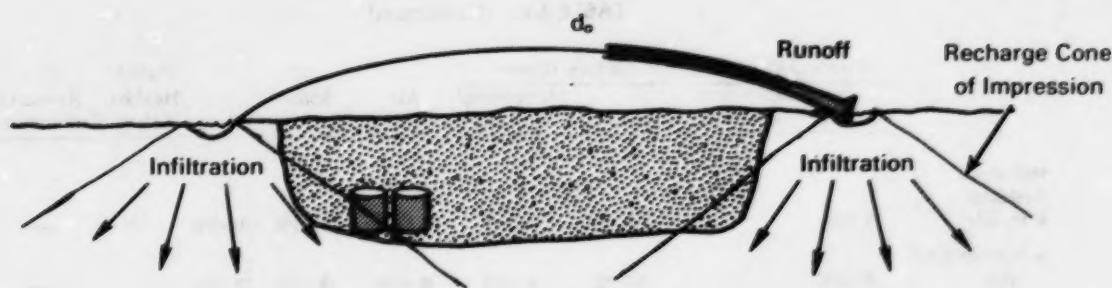


FIGURE 3.1. Example of Lateral Movement of Off-Site Recharge

Blending brought-in soil with existing soil or blending of additives to the existing soil to create capping material will raise fugitive dust. If the surface soil is contaminated with a hazardous material, the fugitive dust may represent both a hazardous air contaminant and an on-site human health and safety hazard. If the surface is uncontaminated, then the fugitive dust represents a nuisance factor. If the fugitive dust is uncontaminated, it can be reduced by water spraying and other measures (see Addendum 1). Application of water or other matter for dust control requires careful planning and monitoring to assure that excess water is not applied or that the material being used for dust control does not interact with the capping medium. The application of excess water can result in increased levels of saturation of the capping material and subsequent increases in the hydraulic conductivity of those materials. Imprudent selection of dust-control liquids could reduce the effectiveness of the cap.

The use of bituminous concrete or bituminous membrane coverings fabricated on site will result in the emission of heavy hydrocarbons. This is an unavoidable effect of use of this technology and only occurs during the period of construction. The effect of these emissions is not significant, in most instances causing only a local and temporary nuisance factor.

3.2 GRADING

Grading is a general term for techniques used to reshape the surface of covered landfills in order to manage surface-water infiltration and runoff while controlling erosion (EPA 1982). The potential effects associated with the use of grading are summarized in Table 3.2 and described in the good engineering practice tables, Tables 3.2a-c, at the end of this section.

Grading consists of a series of construction activities that can be conveniently divided into three groups: slope grading, topsoil haulage, and scarification or contouring. Because the general purpose of grading activities is to divert surface water from the site, these are not expected to cause significant negative effects to ground-water quantity, ground-water movement, or ground-water quality.

During the construction phase and before new vegetation has been established on the site, surface grading and scarification or contouring can leave soils open to erosion. Loose soil provides a potential source of particulates that could be suspended in surface water. If the eroded soils are contaminated with hazardous materials, surface waters potentially could be contaminated with hazardous materials. These effects can be mitigated by using runoff controls and sedimentation basins during construction activities (see Section 3.4 of EPA 1982).

TABLE 3.2. Effects of Surface Controls: Grading

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Slope Grading	—	—	⊙ HPR	● NPR	⊙ HPR	—	⊙ NPR	⊙ HPR	—
	—	—	⊙ NSR	—	⊙ NSR	—	⊙ HPR	—	—
	—	—	—	—	—	—	—	—	—
Topsoil Haulage	—	—	—	—	● NSI	—	—	○ NSI	—
Scarification or Contouring	—	—	⊙ NSR	—	⊙ NSR	—	⊙ NSR	—	—

● = Highly Probable

⊙ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Slope grading is intended to change the patterns of surface-water movement. Changing water movement patterns may change local drainages. This could cause adverse effects by reducing or increasing flow in small streams, possibly causing flooding in the latter case. The potential for this effect should be considered and surface-water diversion and collection measures used if applicable. Reduced flow may be unavoidable.

Slope grading and scarification, being construction-related activities, can potentially raise fugitive dust. If the soil moved during slope grading is contaminated with hazardous materials, the fugitive dust may carry site contaminants off site. These fugitive dusts can affect nearby terrestrial biota. The raising of fugitive dust during construction-related activities can be reduced by the use of water spray and other measures (see Addendum 1).

Hauling topsoil increases traffic along neighboring roads. This traffic will raise fugitive dust and increase noise. These effects are irremediable except that haulage activities may be conducted during the hours of the day when these effects are least noticeable.

If slope grading reduces surface-water discharge to small creeks by diverting flow to another drainage, the reduction in flow of that water body can negatively affect the biota in that water body. Additionally, if the short-term runoff results in silting of the receiving waters, a short-term impact on biota in receiving waters can be expected. A small amount of silt can have a significant effect on the aquatic ecosystem if fish spawning or insect reproduction cycles are affected. If the silt is contaminated with a nondegradable material, then the effect can be expected to be persistent. Likewise, if, during the period of the scarification or contouring activities, sediment loading to receiving waters is increased, negative impacts on biota in receiving waters can be expected. These effects on biota can be mitigated using the same measures used to prevent surface-water quality from deteriorating.

If slope grading transports hazardous material off site via either fugitive dust or sediment, this presents a potential health and safety hazard for off-site populations. This potential negative effect can be mitigated by using the same measures used to control fugitive dusts and surface-water sediments. Topsoil haulage, by increasing local traffic, presents a traffic safety hazard for the communities through which the traffic passes. This is an irremediable but short-term negative effect.

3.3 REVEGETATION

Revegetation establishes a vegetative cover to stabilize the surface of a hazardous-waste site. Revegetation can also be useful in controlling infiltration by increasing transpiration (Beedlow 1984). Proper revegetation will preclude the establishment of deep-rooted species, the presence of which could reduce the effectiveness of other control measures. Thus, revegetation can serve multiple uses as part of a remedial alternative. The potential effects associated with the use of revegetation measures are summarized in Table 3.3 and described in the good engineering practice table, Table 3.3a, at the end of this section.

The vegetative cover should not adversely affect ground water or surface water. However, fertilizers and/or other agricultural chemicals (e.g., herbicides) that may be applied to help establish the vegetation can infiltrate to ground water or run off into surface waters. Species should be selected carefully and agricultural chemicals applied judiciously to avoid contamination.

The type of rooting system of the plants must also be considered. Many plant species have intrusive roots which might penetrate the cap and breach the seal. If the seal is breached, hazardous materials may be released, resulting in potential negative effects on ground-water quality, surface-water quality, soils, biota, and human health and safety. Penetrating roots may take up the hazardous materials and transport them to the surface; breakdown of these roots provides new pathways for the infiltration of water. These effects can be mitigated by restricting the species used for revegetation to those with shallow roots and species that are intensely competitive with deep-root native species. A layer of herbicide between the cap and the surface can be an effective barrier to root penetration by deep-rooted species while permitting establishment of shallow-rooted species.

If the soil on which the vegetative cover is contaminated or if the plant roots penetrate to a contaminated zone, the plants may pick up and incorporate hazardous matter. To guard against public exposure via this route, the vegetative cover should not be used for food for humans or livestock. A long-term monitoring program should continue to examine the vegetative cover for uptake of hazardous matter.

Additionally, revegetation as an element in a remedial action alternative contains the possibility of inadvertent introduction of noxious or poisonous weeds that contaminate the seeds. This possible negative effect can be minimized by specification of the seed content and source region (seed should not be imported from a region where a specific weed species is known to thrive) and by careful follow-up inspection of the site. In some cases, revegetation with native communities may be the best management practice.

TABLE 3.3. Effects of Surface Controls: Revegetation

	Ground-Water		Surface-Water		Air	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Fertilization	●NPR	—	●NSR	—	—	—	—	—	—
Revegetation	●HPR	—	●HPR	—	—	●HPR	●HPR	●HPR	—
	—	—	—	—	—	—	●NPI	—	—

● = Highly Probable

○ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

3.4 SURFACE-WATER DIVERSION AND COLLECTION

Surface-water diversion and collection structures are used to provide short-term or permanent measures to isolate hydrologically waste sites from surface inputs (EPA 1982). These structures are divided into the following categories: dikes and berms; ditches, diversions and waterways; terraces and benches; chutes and downpipes; levees; seepage basins and ditches (recharge basins); and sedimentation basins/ponds. Dikes, berms, ditches, chutes, and downspouts are temporary structures to manage water during remediation activities; diversions, waterways, terraces, and benches are permanent structures or temporary structures, and seepage basins and ditches, levees, and sedimentation basins and ponds are permanent structures. The potential effects associated with the use of surface-water diversion and collection measures are summarized in Table 3.4 and described in the good engineering practice tables, Tables 3.4a-g, at the end of this section.

Surface-water diversion and collection structures are not expected to significantly affect ground-water quality or quantity. However, dikes and berms and some terraces and benches are installed upgradient of the site while ditches, diversions, and waterways will skirt the site. These structures could induce recharge through the waste matter. This can be avoided by developing a clear understanding of the local hydrology and recharge before deciding to install diversion and collection systems.

TABLE 3.4. Effects of Surface Controls: Surface-Water Diversion and Collection

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Dikes and Berms	● HSR	—	● NSR	● NSR	● NSR	—	● NPR	—	—
Ditches, Diversion, and Waterways	● HPR ● HSR	— —	● NPR ● NSR	● NPR ● NSR	● NSR —	— —	● NPR —	● NPR —	— —
Terraces and Benches	● HPR ● HPR	— —	● NSR ● NSR	● NPR ● NSR	● NSR —	— —	● NPR —	— —	— —
Chutes and Downpipes	—	—	● NSR	● NSR	● NSR	—	● NPR	—	—
Levees	—	—	● NSR	● NPR	● NSR	—	● NPR	● NPR	—
Seepage Basins and Ditches (recharge basins)	—	—	● NSR	—	○ NSR	—	○ NPR	○ NPR	—
Sedimentation Basins and Ditches	—	—	○ NSR	—	● NSR	—	● NPR	● NPR	—
Sedimentation Basins/Ponds	— —	— —	○ NSR ○ HPI	— —	● NSR —	— —	● NSR —	— —	— —

● = Highly Probable

● = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

R = Reversible (or mitigable)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

The use of surface-water diversion and collection structures is not expected to affect surface-water quality except during the construction of these structures. Before the building material is stabilized, runoff may carry increased amounts of sediment. If the sediment reaches receiving waters, it will adversely affect biota by reducing habitat. Additionally, if the short-term runoff results in silting of the receiving waters, a short-term impact on biota in receiving waters can be expected. A small amount of silt can have a significant effect on the aquatic ecosystem if fish spawning or insect reproduction cycles are affected. This can be mitigated via the early installation of sedimentation basins or ponds for which this effect is self-mitigating. A possible, but unlikely, negative effect of the use of sedimentation basins or ponds to prevent the transport of contaminated sediments off site would occur from a greater-than-design flood that could release the trapped contaminated sediments into the environment. This effect is unavoidable, but very unlikely.

The use of surface-water diversion and collection methods, by design, affects the destination of overland flow. This can result in adverse effects on wildlife if the flow to streams or wetlands is significantly reduced. The use of levees to prevent floodwaters from encroaching on the hazardous-waste site will tend to increase flood potential immediately upstream or downstream. These are unavoidable adverse effects of this technology.

During the construction of these structures or decommissioning of temporary structures, fugitive dust may be raised. Fugitive-dust emissions may be reduced by the use of water spraying and other techniques (see Addendum 1).

In addition to effects on aquatic biota from increased sediment loadings during construction, ditches, diversions and waterways; levees; and seepage basins and ditches will catch water in a way that will provide breeding grounds for insects. Low spots in ditches, diversions and waterways can trap small pockets of water. Seepage basins and ditches generally hold standing water, especially after use has led to some silting. Levees can prevent runoff from reaching receiving waters, but the runoff will pond on the uphill side of the levee providing a potential breeding ground for insects. Creation of insect breeding grounds can be minimized by maintenance activities. Ditches, diversions and waterways should be inspected so that ponding can be found and corrected. When seepage basins have silted such that water is retained for extended periods of time, these must be rehabilitated. Upslope collection areas should be designed in tandem with the levee and pumped regularly. An additional potential negative effect of seepage basins and ditches is that humans and other biota may be trapped in them if the sides are too steep and the structures too deep. For safety, these should be fenced. To prevent impacts on biota, the sides should not be so steep as to trap small animals. Small animal control should be an element of diversion measure management because animal burrows can compromise the integrity of earthen barriers, which can result in failure.

TABLE 3.1a. Surface Controls: Surface Sealing—Soil Blending

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	if surface soil is contaminated, blending operations may raise contaminated fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust (contaminated or uncontaminated) from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above
Public Health or Safety	contaminated fugitive dust from capping activities can carry hazardous material off site	see air quality above

TABLE 3.1b. Surface Controls: Surface Sealing—Blending in Cements/Stabilizers

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	if surface soil is contaminated, blending operations may raise contaminated fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust (contaminated or uncontaminated) from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above
Public Health or Safety	contaminated fugitive dust from capping activities can carry hazardous material off site	see air quality above

Table 3.1c. Surface Controls: Surface Sealing—Soil Treating

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	if surface soil is contaminated, blending operations may raise contaminated fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust (contaminated or uncontaminated) from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above
Public Health or Safety	contaminated fugitive dust from capping activities can carry hazardous material off site	see air quality above

TABLE 3.1d. Surface Controls: Surface Sealing—Clay Capping

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1e. Surface Controls: Surface Sealing—Portland Cement, Concrete, or Mortar

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	runoff from soils disturbed during capping activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1f. Surface Controls: Surface Sealing—Bituminous Concrete Covering

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	bituminous concrete construction will result in emission of heavy hydrocarbons	none; unavoidable, but brief effect of this technology
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1g. Surface Controls: Surface Sealing—Bituminous Membrane Covering

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	bituminous concrete construction will result in emission of heavy hydrocarbons	none; unavoidable, but brief effect of this technology
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1h. Surface Controls: Surface Sealing—Sprayed Sulfur/Polyurethane Membranes

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1i. Surface Controls: Surface Sealing—Poly (Vinyl Chloride, Ethylene, etc.) Covers

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.1j. Surface Controls: Surface Sealing—Industrial Residues

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if run-on and runoff waters are not disposed of properly, lateral infiltration can result in ground-water contamination	understand ground-water hydrology in sufficient detail to know fate of diverted waters
	fly ash, bottom ash and slag, furnace slag, and incinerator residue contain heavy metals that leach and contaminate ground water	select and test candidate capping material carefully
	nontoxic industrial sludges and composted sewage sludge may contain significant quantities of objectionable matter that can leach and contaminate ground water	select and test candidate capping material carefully
	leachates from industrial residue can change groundwater chemistry and mobilize toxics	select and test candidate capping material carefully
Surface-Water Quality	increased runoff as a result of capping can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Soils/Geology	increased runoff as a result of capping can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust from capping can affect nearby biota	prevention is key (see air quality above); remediation difficult
	erosion can remove terrestrial habitat	see soils/geology above
	sediment from erosion and increased runoff can affect aquatic biota	see soils/geology above

TABLE 3.2a. Surface Controls: Grading—Slope Grading

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during grading activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	if soil is contaminated, runoff can carry contaminated sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	increased runoff as a result of grading can cause erosion and carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate surface-water diversion and collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4); decreased flow may be unavoidable
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	if surface soil is contaminated, grading operations may raise contaminated fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
Soils/Geology	increased runoff as a result of grading can cause erosion	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Biota	fugitive dust (contaminated or uncontaminated) from grading can affect nearby biota	prevention is key (see air quality above); remediation difficult
	sediment (contaminated or uncontaminated) from grading or changed flow patterns can affect aquatic biota	see surface-water quality above
	changed flow in receiving waters can affect resident aquatic biota	see surface-water quantity above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from grading activities can carry hazardous material off site	see air quality and surface-water quality above

TABLE 3.2b. Surface Controls: Grading—Topsoil Hauling

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	hauling activities will result in release of fugitive dusts along route	none; unavoidable; schedule hauling so that effect is minimized
	hauling activity will result in noise along the route	none; unavoidable; schedule hauling so that effect is minimized
Public Health or Safety	hauling activities increase traffic safety hazard along truck routes	none; unavoidable; route and schedule hauling to minimize effect

TABLE 3.2c. Surface Controls: Grading—Scarification or Contouring

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Surface-Water Quality	runoff from soils disturbed during contouring activities can carry sediment to receiving waters	incorporate revegetation as appropriate (see EPA 1982, Section 3.3)
Air Quality	contouring activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust from contouring activities can affect nearby biota	prevention is key (see air quality above); remediation difficult
	sediment carried to receiving waters can affect resident biota	see surface-water quality above

TABLE 3.3a. Surface Controls: Revegetation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	fertilizers and/or other agricultural chemicals can infiltrate and contaminate ground water	careful selection and judicious application of chemicals
	root system can breach capping and lead to ground-water contamination	select shallow-rooted species; apply thin herbicide layer between cap and surface
Surface-Water Quality	root system can breach capping and lead to surface-water contamination	see ground-water quality above
	facilities and or other agricultural chemicals can run off and contaminate ground water	careful selection and judicious application of chemicals
Soils/Geology	root system can breach capping and lead to soil contamination	see ground-water quality above
Biota	root system can breach capping and vegetation can take up contaminants, introducing toxics into food chain	see ground-water quality above
	noxious or poisonous plant species may be inadvertently introduced	use native communities, if possible; otherwise, specify seed content and place of origin
Public Health or Safety	root system can breach capping leading to public exposure	see ground-water quality above
	if soil is contaminated or roots penetrate waste, plants can take up toxics and expose public via food chain	establish and enforce policy of not using vegetative cover for food for humans or livestock

TABLE 3.4a. Surface Controls: Surface-Water Diversion and Collection—Dikes and Berms

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	dikes and berms, being upgradient of the site, could induce recharge through the waste and contaminate ground water	develop a clear understanding of area hydrology and implications of technology before deciding to use
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate sedimentation basins or ponds early in remediation process (see EPA 1982, Section 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate seepage basin or ditch early in remediation process (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult

TABLE 3.4b. Surface Controls: Surface-Water Diversion and Collection—Ditches, Diversions, and Waterways

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	ditches, diversions, and waterways skirt the site and could cause recharge through the waste and contaminate ground water	develop a clear understanding of area hydrology and implications of technology before deciding to use
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate sedimentation basins or ponds early in the remediation process (see EPA 1982, Section 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate seepage basins early in the remediation process (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult
Public Health or Safety	low spots can hold water and establish a breeding ground for insects	establish and enforce an inspection and maintenance program

TABLE 3.4c. Surface Controls: Surface-Water Diversion and Collection—Terraces and Benches

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	upgradient terraces or benches could induce recharge through the waste and contaminate ground water	develop a clear understanding of area hydrology and implications of technology before deciding to use
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate sedimentation basins or ponds early in the remediation process (see EPA 1982, Section 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate seepage basin or ditch early in the remediation process (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult

TABLE 3.4d. Surface Controls: Surface-Water Diversion and Collection—Chutes and Downspouts

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate sedimentation basins or ponds early in the remediation process (see EPA 1982, Section 3.4)
Surface-Water Movement	changed runoff patterns can change flow in receiving waters	if increased flow will be a problem, incorporate seepage basin or ditch early in the remediation process (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult

TABLE 3.4e. Surface Controls: Surface-Water Diversion and Collection—Levees

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	temporary, but may be unavoidable; temporary sedimentation basin or pond might be used (see EPA 1982, Section 3.4)
Surface-Water Movement	levees to prevent on-site flooding will tend to increase off-site flooding directly upstream	none; unavoidable aspect of use of this technology
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult
Public Health or Safety	runoff collecting on the uphill side of the levee can provide a breeding area for noxious insects	include upslope collection area in design, and pump regularly

TABLE 3.4f. Surface Controls: Surface-Water Diversion and Collection—Seepage Basins and Ditches

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate sedimentation basins or ponds early in the remediation process (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust or sediment resulting from construction can affect nearby biota	prevention is key (see air quality and surface-water quality above); remediation difficult
	seepage basins and ditches may trap small wildlife	walls should not be steep enough to trap wildlife
Public Health or Safety	seepage basins and ditches that have been in use for some time generally hold standing water and, therefore, can be breeding grounds for noxious insects	establish and enforce schedule for inspection and rehabilitation
	deep seepage basins and ditches may be a public hazard if people can fall in them	establish security to control public access

4.0 GROUND-WATER CONTROLS

Ground-water controls are implemented to prevent contaminated ground water from migrating away from the uncontrolled hazardous-waste site or to divert ground water to prevent contact with waste materials.

4.1 IMPERMEABLE BARRIERS

Impermeable barriers are used to divert ground-water flow away from an uncontrolled hazardous-waste site or to contain contaminated ground water at the site. Three impermeable-barrier methods used to control ground-water movement are addressed in EPA 1982: slurry walls, grout curtains, and sheet-piling cutoff walls. The potential effects associated with the use of impermeable barriers are summarized in Table 4.1 and described in the good engineering practice tables, Tables 4.1a-c, at the end of this section.

Certain potential adverse environmental effects are common to all of these impermeable barrier methods for controlling ground water. Impermeable barriers will, by design, divert ground-water flow. Diverting the flow will increase ground-water heads in some areas bordering the site and decrease heads in others. If these increased heads intercept the surface or manmade structures, significant nuisance effects may occur. For instance, if the local water table intercepts the surface, seeps and springs will be formed. Aside from the direct nuisance caused by seeps and springs, there may be an effect on the utility of the soil for agricultural use where they occur. If the head is increased such that the local water table intercepts basements or sewer lines, basement flooding, sewer-line backup, or overload of the sewer system is possible. If the change in head creates new discharge to local surface waters or reduced discharge to other surface waters, small streams and the biota inhabiting these streams and the riparian areas may be adversely affected. These adverse effects can best be remedied by studying in detail how the planned remedial action will affect the local water table before taking

TABLE 4.1. Effects of Ground-Water Controls: Impermeable Barriers

	Ground-Water		Surface-Water		Air	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
All Methods	—	● NPR	● NPR	● NPR	● NSR ● HPR	● NPR	● NSR ● HPI	— ● HPI	—
Slurry Walls	○ HPR	—	—	—	● HPR	—	—	—	—
Grout Curtains	○ HPR	—	—	—	● HPR	—	—	—	—
Sheet-Piling Cutoff Walls	—	—	—	● NSI	—	—	—	—	—

● = Highly Probable

○ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

action. If impermeable barriers are deemed to be absolutely necessary but the change in the water table causes negative effects off site by intercepting manmade structures or the surface, then additional off-site ground-water controls such as impermeable barriers or drains, may be required to prevent these negative effects. All studies of the effect of the impermeable barriers on the local water table should consider seasonal variations and include future human activities that may affect the local water table (e.g., irrigation or off-site residential development).

Because each of the impermeable barrier methods involves construction activities, with consequent local soil disruption, fugitive dust could be released either containing or not containing hazardous material. These fugitive dusts may affect nearby biotic communities. In addition, runoff from the disturbed area can contribute to sediment loading in local surface waters with consequent effect on biota inhabiting the waters. Contaminated fugitive dust or sediments transported off site can present a hazard to public health. Fugitive dust emitted during construction-related activities can be reduced by water spraying or other measures (see Addendum 1). Surface-water diversion and collection measures together with revegetation (see Sections 3.3 and 3.4 of EPA 1982) can prevent surface-water quality from being degraded as a result of these construction activities.

The use of impermeable barriers to control ground water may interact with measures taken to control gaseous releases and adversely affect the ventilation of the hazardous-waste site (see Sections 6 of EPA 1982 and of this document). If ventilation is affected, noxious or hazardous vapors could be released with potential exposure to humans and biota. Remedying this potential effect simply involves considering potential interactions between measures taken.

A possible effect specific to slurry wall construction is that, during excavation, an aquitard may be breached or damaged, connecting a contaminated aquifer to an uncontaminated aquifer. If this were to occur, some remedy of the contamination of the new aquifer would be required. Damage to the aquitards should be carefully avoided through detailed study of the hydrology and devising and enforcing excavation procedures before beginning operation.

During the construction of grout curtains, numerous holes are drilled to bedrock or to a significant aquitard encircling the uncontrolled hazardous-waste site. Each of the holes could potentially penetrate an aquitard and connect an uncontaminated aquifer to a contaminated aquifer. Again, the best remedy for this potential effect is to prevent its occurrence by carefully logging the material through which the hole is being drilled. If such penetration does occur, the hole should be sealed with a physically strong and impermeable material and monitored.

Additionally, some of the grouts that are described for use for grout curtains (EPA 1982) are themselves toxic and/or noxious (for instance, the lignochromium and acrylamide grouts). Use of lignochromium grouts (which are based on hexavalent chromium) could potentially contaminate ground water or, if spilled on site, contaminate the soils. Soil contamination from spills can be remedied by cleanup after the grouting operation. Acrylamide has been recognized as a neurotoxin and since 1979 has not been marketed for grouting purposes in the United States (Shafer et al. 1984); the most significant hazard in the use of acrylamide grouts was to the worker because the material polymerizes quickly after contact with the soil.

The use of sheet-piling cutoff walls requires a pile driver to insert the sheet piling. Inevitably, the pile driver creates a noise nuisance factor. Although irremediable, this effect is short term and can be mitigated in part by operating only during midday hours.

4.2 PERMEABLE TREATMENT BEDS

Permeable treatment beds treat ground water in situ by intercepting ground-water flow with material that can remove contaminants. Such material could be limestone, activated carbon, zeolites, locally obtained glauconitic green sands, or synthetic ion-exchange resins. After the contaminated ground-water plume has been successfully treated or the treatment bed is exhausted, the treatment bed would have to be removed and disposed of as contaminated material. The potential effects associated with the use of permeable treatment beds are summarized in Table 4.2 and described in the good engineering practice table, Table 4.2a, at the end of this section.

The treatment material, after being removed, could potentially contaminate ground waters at the disposal site. The contaminants can remobilize if water chemistry at the new site differs from that at the originating area. Therefore, the treatment medium must be disposed of as a hazardous material in a Resource Conservation Recovery Act (RCRA)-approved site.

Permeable treatment beds are constructed by excavation to below the water table. If the ground water is contaminated where the bed is being constructed, the material through which the ground water flows (i.e., the material being excavated) must be presumed to be contaminated. If the contaminated soils are not disposed of promptly, these may dry and form a source of contaminated fugitive dust, thereby transporting the contaminant off site where biota and human health and safety may be affected. Soils also could be contaminated off site by these fugitive dusts. To prevent contamination off site, the contaminated soils should be disposed of properly before they can dry and become sources of fugitive dusts.

Also, these construction activities have the potential for releasing fugitive dusts from surface activities; construction-related emissions of uncontaminated fugitive dusts can be minimized by keeping the disturbed soils damp by water spraying and by other measures (see Addendum 1).

Construction-related activities can also cause increased sediment loading to nearby surface waters by disturbing surface cover. In addition, if the contaminated soils are not disposed of properly and promptly, the sediment carried to surface water may be contaminated with the hazardous material. These potential effects could be mitigated by proper handling and prompt disposal of the contaminated soils and treating the runoff water from these soils as contaminated. Surface-water diversion and collection measures together with revegetation (see EPA 1982) can prevent uncontaminated sediments from increasing sediment loading to nearby surface waters.

TABLE 4.2. Effects of Ground-Water Controls: Permeable Treatment Beds

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● NPR	—	● NSR	● HPR	● HPR	● HPR	—
—	—	● HSR	—	● HSR	—	—	—	—

● = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

4.3 GROUND-WATER PUMPING

Ground-water pumping is effected to accomplish three possible goals: 1) to lower the water table locally and prevent ground water from contacting the waste, 2) to contain a contaminated plume, or 3) to extract contaminated ground water for subsequent treatment. The potential effects associated with the use of impermeable barriers are summarized in Table 4.3 and described in the good engineering practice table, Table 4.3a, at the end of this section.

Pumping ground water to lower the water table or to contain a contaminant plume involves handling only uncontaminated water and drilling through uncontaminated media. In this case, potential negative effects are the long-term commitment of energy for pumping and, if the pumped water is discharged to surface waters, the effects of increased flows resulting from the discharge on surface-water movement and quantity and on the biota inhabiting those surface waters. An alternative to surface-water discharge of the pumped water is to return the water to the aquifer, either through injection wells or percolation basins. This approach has the additional advantage that it may (although not necessarily will) contribute to the efficiency of the plume management or water-table management if designed accordingly.

If the ground water is pumped to remove contaminated ground water for subsequent treatment, the construction of the well probably involves drilling through and into contaminated media. (The negative effects of ground-water treatment options are discussed in Appendix B.) If the drill cuttings are not handled as contaminated material and are allowed to lie where they fall, these can contaminate the soil, degrade air quality as contaminated fugitive dust, and degrade surface-water quality as contaminated suspended sediment. These contaminants can, in turn, negatively affect local biota and human health and safety. These effects can be prevented by handling the drill cuttings and any material removed from the well as hazardous material. Proper development of the capture well will probably require the removal of significant quantities of sediment-laden water from the wells. Since well completion may very possibly occur before completion of the water-treatment facility, the water and sediment will have to be stored and handled as hazardous material.

After treatment, the treated ground water must be disposed of. The negative effects of disposing of contaminated water from pumping will depend on the method of disposal. If it is disposed of to surface

TABLE 4.3. Effects of Ground-Water Controls: Ground-Water Pumping

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	⊙ HPR	⊙ NPR	● NSR ⊙ HPR	⊙ HPR	⊙ HPR	⊙ HPR	● NPI
—	—	⊙ NSR	—	● NSI	—	⊙ NPR	—	—

● = Highly Probable

⊙ = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

R = Reversible (or mitigable)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

waters, it could affect surface-water movement and quantity and potentially affect the surface-water biota because of increased flows. The remedy for these potential negative effects is to reinject the water through wells or percolation basins.

Another potential negative effect of ground-water pumping is the noise of drilling during construction. This effect, although irremediable, is short term and only lasts during the process of construction. The noise-related environmental insult can be remedied in part by confining drilling to normal working hours.

4.4 INTERCEPTOR TRENCHES

See Section 5.2: Drainage Ditches and Table 4.4.

TABLE 4.4. Ground-Water Controls: Interceptor Trenches

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					

SEE SECTION 5.2; DRAINAGE DITCHES

- = Highly Probable ① = Probable ○ = Improbable
 - N = Nuisance H = Hazardous — = No significant effects predicted
 - S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 - R = Reversible (or mitigable) I = Irreversible (unmitigable)
- NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

4.5 BIORECLAMATION

Bioreclamation involves the in situ destruction of ground-water contaminants by exotic biota. In this process, microorganisms are introduced into the ground water together with nutrients, and the ground water is aerated. The potential effects associated with the use of bioreclamation are summarized in Table 4.5 and described in the good engineering practice table, Table 4.5a, at the end of this section.

The construction of the well involves drilling through and into contaminated media. If the drill cuttings are not handled as contaminated material and are allowed to lie where they fall, these can contaminate the soil, degrade air quality as contaminated fugitive dust, and degrade surface-water quality as contaminated suspended sediment. These contaminants can, in turn, negatively affect local biota and human health and safety. These effects can be prevented by handling the drill cuttings and any material removed from the well as hazardous material. Proper development of the well will probably require removal of significant quantities of sediment-laden water from the wells. Since well completion may very possibly occur before completion of a water treatment facility (if any is to be constructed) the water and sediment will have to be stored or disposed of as hazardous material.

Another potential negative effect of bioreclamation is the noise of drilling during well construction. This effect, although irremediable, is short term and only lasts during the process of construction. The noise-related environmental insult can be remedied, in part, by confining drilling to normal working hours.

TABLE 4.5. Ground-Water Controls: Bioreclamation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● NPR	—	○ HPR	—	○ HPR	● HPR	● HPR	● HPR	—
● NPR	—	—	—	● NSR	—	● NPR	—	—
—	—	—	—	● NSI	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

○ = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Other negative effects associated with bioreclamation include further ground-water contamination because nutrients can migrate away from the site and into drinking waters. Finally, the microorganisms could potentially be released outside of the site area. Although this effect may be more serious in its perception by the public ("you're putting bugs into my drinking water") than real, it must still be considered.

TABLE 4.1a. Ground-Water Controls: Impermeable Barriers—Slurry Walls

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	excavation may breach aquitard, thereby contaminating an additional aquifer	know hydrology in detail; devise and enforce procedures for excavation
Ground-Water Movement	increased heads may intercept land surface resulting in seeps or springs	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
	increased heads may intercept manmade structures resulting in flooding or sewer overload	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	altered ground-water flow may affect water transfer to surface waters and change stream flow	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Air Quality	construction activities can result in release of fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
	excavation to aquitard can bring contaminated soils to surface where these can become contaminated fugitive dusts	control of contaminated fugitive dust (see Addendum 1)
	this measure can interfere with ventilation measures (if used) resulting in airborne vapor release	consider possible interactions between measures
Soils/Geology	surface seeps or springs (see ground-water movement above) may reduce land utility	see ground-water movement above
Biota	changed surface-water flow (see surface-water movement above) may affect resident biota	see surface-water movement above
	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off the site and expose public	see air quality and surface-water quality above

TABLE 4.1b. Ground-Water Controls: Impermeable Barriers—Grout Curtains

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	drilling may breach aquitard, thereby contaminating additional aquifer	know hydrology in detail; devise and enforce procedures for drilling; if breach of aquitard occurs, seal entire drill hole
	lignochromium grouts may contaminate ground water	be certain that grouts are chemically suitable for on-site conditions
Ground-Water Movement	increased heads may intercept land surface resulting in seeps or springs	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
	increased heads may intercept manmade structures resulting in flooding or sewer overload	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	altered ground-water flow may affect water transfer to surface waters and change stream flow	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	drilling to aquitard can bring contaminated soils to surface where these can become contaminated fugitive dusts	handle drill cuttings as hazardous matter
	this measure can interfere with ventilation measures (if ventilation is used) resulting in airborne vapor release	consider possible interactions between measures
Soils/Geology	surface seeps or springs (see above) may reduce land utility	see ground-water movement above
	spills of toxic grouts may contaminate surface soils	plan for spills by using dedicated material handling area; plan to clean up area
Biota	changed surface-water flow above may affect resident biota	(see surface-water movement above)
	fugitive dust (contaminated or uncontaminated) from drilling can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from drilling operation can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from drilling activities can carry hazardous material off the site	see air quality and surface-water quality above

TABLE 4.1c. Ground-Water Controls: Impermeable Barriers—Sheet-Piling Cutoff Walls

Affected Area	Effect	Mitigation Measure
Ground-Water Movement	increased heads may intercept land surface resulting in seeps or springs	model off-site changes in water table, potential land-use changes; install off-site ground-water controls if needed
	increased heads may intercept manmade structures resulting in flooding or sewer overload	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Movement	altered ground-water flow may affect water transfer to surface waters and change stream flow	model off-site changes in water table, including potential land-use changes; install off-site ground-water controls if needed
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	this measure can interfere with ventilation measures (if used) resulting in airborne vapor release	consider possible interactions between measures
	pile-driver installation of sheet-piling cutoff walls will create noise	schedule pile-driver operating hours to reduce public nuisance
Soils/Geology	surface seeps or springs (see ground-water movement above) may reduce land utility	see ground-water movement above
Biota	changed surface-water flow (see above) may affect resident biota	see surface-water movement above
	fugitive dust (contaminated or uncontaminated) from construction activities can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from construction activities can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from construction activities can carry hazardous material off the site	see air quality and surface-water quality above

TABLE 4.2a. Ground-Water Controls: Permeable Treatment Beds

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	treatment material may contaminate ground waters at site of disposal	handle spent treatment-bed material as contaminated matter; dispose of in a RCRA-approved site
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	excavation into aquifer can bring contaminated soils to surface where these can be carried to receiving waters by overland flow	handle and dispose of excavated material as contaminated matter
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	excavation into aquifer can bring contaminated soils to surface where these can become contaminated fugitive dusts	handle and dispose of excavated material as contaminated matter
Soils/Geology	excavation into aquifer can bring contaminated soils to surface where these can contaminate surface soils	see air quality above
Biota	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off the site	see air quality and surface-water quality above

TABLE 4.3a. Ground-Water Controls: Ground-Water Pumping

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff of soils contaminated by drill cuttings or development water may contaminate surface water	see soils/geology below
Surface-Water Movement	discharge of pumped water to receiving waters will increase surface-water flows	if adverse effects can result from increased flow, use reinjection wells or use percolation basins
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	soils contaminated by drill cuttings or development water may form contaminated fugitive dusts	see soils/geology
	drilling will produce noise	none; unavoidable but temporary, reduce effect of noise by scheduling drilling
Soils/Geology	drill cuttings may contaminate soil	handle and dispose of drill cuttings as hazardous matter
	water pumped from well to develop well may contaminate soil	handle development waters as hazardous matter and store for treatment
Biota	changed surface-water flow (see above) may affect resident biota	see surface-water movement above
	fugitive dust (contaminated or uncontaminated) from activity can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from activity can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from drilling or well development activities can carry hazardous material off the site	see air quality and surface-water quality above
Resource Commitments	use of ground-water pumping to isolate waste involves commitment of energy and other resources for pumping for an indefinite period	none; unavoidable effect of this technology
	use of pump-and-treat option involves commitment of energy and other resources for period of treatment	none; unavoidable effect of this technology

TABLE 4.5a. Ground-Water Controls: Bioreclamation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	nutrients introduced to assist microbiota may contaminate nearby drinking waters	mitigation difficult; careful study of ground-water flow, monitoring of treated flow, and planning are key
	microorganisms introduced to degrade toxic matter may be released off site	primarily a public perception issue; mitigable by education
Surface-Water Quality	runoff from soils disturbed during drilling activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff of soils contaminated by drill cuttings or development water may contaminate surface water	see soils/geology below
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	soils contaminated by drill cuttings or development water may form contaminated fugitive dusts	see soils/geology below
	drilling will produce noise	none; unavoidable, but temporary; reduce effect of noise by scheduling drilling
Soils/Geology	drill cuttings may contaminate soil	handle and dispose of drill cuttings as hazardous matter
	water pumped from well to develop well may contaminate soil	handle development waters as hazardous matter and store for treatment
Biota	fugitive dust (contaminated or uncontaminated) from activity can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from activity can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from drilling or well development activities can carry hazardous material off the site	see air quality and surface-water quality above

5.0 LEACHATE COLLECTION AND TREATMENT

Leachate is defined as the contaminated liquid discharged from a waste disposal site to either surface or subsurface receptors. Leachate collection systems consist of a series of drains that intercept the leachate and channel it to an ultimate treatment point. The drains may consist of open ditches or trenches or pipe or tile drain fields. To a limited extent, liners may be used to assist in leachate collection.

5.1 SUBSURFACE DRAINS

Subsurface drains consist of underground gravel-filled trenches lined with tile or perforated pipe. These drains intercept leachate (or infiltrating water destined to become leachate) and transport this water to a treatment point (or disposal point, as appropriate). The potential effects of the use of subsurface drains are summarized in Table 5.1 and described in the good engineering practice table, Table 5.1a, at the end of this section.

The most serious potential adverse effect associated with the use of subsurface drains is that this method is only effective in saturated soils because the drains will only collect leachate below the local water table (this restriction does include a perched water table). Thus, if the water table changes significantly with season, leachate may move by unsaturated-zone transport and escape a collection system consisting of subsurface drains, or infiltrating water may escape the drains and become leachate, leading to contamination of ground water. Therefore, relying on subsurface drains may lead to a false sense of security because the drains may be dry, while, in fact, the leachate is going around the drains. A possible remedy for this effect is to create a perched aquifer by engineering an under-landfill liner (see Section 5.3 of this document and of EPA 1982). However, this remedy is fraught with potential hazard and success is not certain.

Other potential adverse effects from subsurface drains are related to construction activities that disturb the surface. Fugitive dusts can degrade air quality, but can be controlled by water spraying and other methods (see Addendum 1). Runoff from disturbed soils can affect surface-water quality and the biota inhabiting that surface water. These effects may be prevented through the use of surface-water diversion and collection methods together with revegetation (see Sections 3.3 and 3.4 of EPA 1982).

TABLE 5.1. Leachate Collection and Treatment: Subsurface Drains

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● NSR	—	● NSR	● HPR	● NPR	● NPR	—
—	—	● HPR	—	● HPR	—	● HPR	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

If the subsurface drain is intended to collect leachate, excavation very probably will proceed into a contaminated zone. If the excavated soils are not handled accordingly, fugitive dusts and surface runoff from these contaminated soils can be a hazard both to neighboring biota and man. These potential adverse effects can be remedied by treating the excavated material as hazardous and disposing of it accordingly.

5.2 DRAINAGE DITCHES

Drainage ditches can be used for two purposes in remedial action. First, they can collect or divert ground water as part of a ground-water-control strategy (see Section 4.4 of EPA 1982). Second, drainage ditches can be used as part of a leachate collection system for subsequent treatment. The potential effects of the use of drainage ditches are summarized in Table 5.2 and described in the good engineering practice table, Table 5.2a, at the end of this section.

Regardless of the purpose, the construction of the drainage ditches can cause adverse effects on surface-water quality, air quality, and biota. Sediment carried from the construction site by overland flow can degrade surface-water quality in receiving streams and can adversely affect biota residing in those streams. This can be prevented by using surface-water diversion and collection methods together with revegetation (see Sections 3.3 and 3.4 of EPA 1982) as part of the overall site activity.

Air quality can be degraded as a result of fugitive dust from construction activities. This can be controlled via the appropriate use of water spraying or other methods (see Addendum 1).

If the trench is being constructed to intercept leachate, it is highly probable that the excavated soil will be contaminated with the hazardous material. This soil can become airborne or carried to receiving streams by overland flow unless specific measures are taken. In either case, the contaminants being transferred off site may present a hazard for man and biota. This effect can be prevented by treating the contaminated soil as hazardous matter and disposing of it in an appropriate fashion.

TABLE 5.2. Leachate Collection and Treatment: Drainage Ditches

	Ground-Water		Surface-Water		Air Quality	Soils/Geology	Biota	Public Health/Safety	Resource Commitments
	Quality	Movement/Quantity	Quality	Movement/Quantity					
Collect & Divert Ground Water	—	—	● NSR	● NPR	● NSR	—	● NSR	● NPR	—
	—	—	—	—	● HPR	—	● NPR	—	—
Collect Leachate for Treatment	—	—	● NSR	—	● NSR	—	● NSR	● HPR	—
	—	—	● HPR	—	● HPR	—	● HPR	● NPR	—
	—	—	—	—	—	—	● NPR	—	—

● = Highly Probable

● = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Drainage ditches are generally from six to twelve feet deep and are intended to hold standing water or leachate (EPA 1982). A six-to-twelve-foot-deep trench filled with water forms a potential trap for man and terrestrial biota. The hazard to human safety can be remedied by additional security, fencing, and other measures. By covering the drain, the hazard to terrestrial biota can be mitigated as well.

The standing water in the trenches also forms a potential breeding ground for mosquitoes and other noxious insects. As such, these ditches could be judged to be a public nuisance. Also if a riparian zone is allowed to develop around the standing water, the trench can tend to become an attractive environment for birds and mammals. If the standing water or vegetation contains biota that are food for game birds, a pathway to the human food chain may be created. The ditches can be prevented from becoming a breeding ground by covering them or maintaining an oil film on the standing water. Vegetative growth can be prevented through herbicide application. The use of any additive must be considered in regard to the effect of that additive on the overall treatment package.

If the drainage trench is being used specifically to collect and divert ground-water flow, the quantity and movement of the receiving water into which this ground water is discharged may be affected, along with the biota that inhabit these receiving waters. This effect can be prevented by using percolation basins or injection wells as part of the ground-water-control strategy.

5.3 LINERS

As noted in Section 5.1, drains are only effective when operating below the local water table. The use of an under-the-waste liner can create a perched water table of leachate and, thereby, make such subsurface drains effective. The potential effects of the use of liners are summarized in Table 5.3 and described in the good engineering practice tables, Tables 5.3a and b, at the end of this section.

EPA (1982) describes two methods for creating under-waste liners. The first, under-waste grouting, involves drilling through the waste and grouting the soil beneath. The second involves slurring bentonite into an existing lagoon; the bentonite would then settle to the bottom and consolidate to form a liner.

TABLE 5.3. Leachate Collection and Treatment: Liners

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Under-Waste Grouting	—	—	⊙ HPR	—	⊙ HPR	⊙ HPR	⊙ HPR	○ HPR	—
	—	—	⊙ NSR	—	● NSR	—	—	⊙ HPR	—
Bentonite Slurry	—	—	—	—	⊙ NSR	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

⊙ = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Implementing under-waste grouting involves drilling through the waste or the use of slant-drilling techniques. Drilling into waste is recognized to be a hazardous activity. Waste-disposal sites have been known to contain compressed gases and pyrophoric and explosive materials. A fire or explosion initiated by the drilling process would release hazardous material that could be a persistent hazard to human health and safety and biota. This contamination could also cause a persistent degradation of surface-water quality and contamination of soils in the vicinity.

Drill cuttings also will very likely be contaminated with hazardous matter. If they are left as they lie, they can evolve into contaminated fugitive dust or contaminated sediments in runoff, thereby degrading air quality and surface-water quality, respectively. This effect is mitigated by treating the drill cuttings as hazardous matter and disposing of them accordingly. Slant drilling under the waste is a possible alternative to drilling through the waste. This option is, however, very expensive and subject to limited applicability.

Construction-related activities at the site associated with the drilling and grouting will disturb surface soils and create fugitive dusts. The fugitive dust will degrade air quality; this can be remedied in part by water spraying and other methods (see Addendum 1).

Disturbing the surface cover also will lead to sediment in runoff. This can be prevented through the use of surface-water diversion and collection measures together with revegetation (see Sections 3.3 and 3.4 of EPA 1982).

The use of powdered bentonite to form a slurry can result in fugitive dust, which can degrade air quality. This effect is transitory, lasting only during the period during which the bentonite is being applied. It may be mitigated by applying the bentonite as a slurry.

5.4 TREATMENT

See Appendix B and Table 5.4.

TABLE 5.4. Leachate Collection and Treatment: Treatment

Ground-Water		Surface-Water		Air	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					

SEE APPENDIX B

- = Highly Probable ① = Probable ○ = Improbable
 - N = Nuisance H = Hazardous — = No significant effects predicted
 - S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 - R = Reversible (or mitigable) I = Irreversible (unmitigable)
- NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

TABLE 5.1a. Leachate Collection and Treatment: Subsurface Drains

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	if drained region becomes unsaturated, drains will be ineffective and leachate may escape collection leading to ground-water contamination	ensure that drained region is saturated year-round; alternative is to create perched water table by engineering an under-landfill liner (see EPA 1982, Section 5.3)
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters runoff containing excavated matter may carry contaminated sediments to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4) see soils/geology below
Air Quality	construction activities can result in release of fugitive dusts contaminated soil resulting from excavation can become contaminated fugitive dusts	fugitive-dust control (see Addendum 1) see soils/geology below
Soils/Geology	excavated matter may contain hazardous material and may contaminate soils	contain excavated material and handle as contaminated matter
Biota	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	prevention is key (see air quality above); remediation is difficult see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off the site and expose public	see air quality and surface-water quality above

TABLE 5.2a. Leachate Collection and Treatment: Drainage Ditches

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff containing excavated matter may carry contaminated sediments to receiving waters	see soils/geology below
Surface-Water Quality	drainage ditches to collect and divert ground-water flow may affect flow of surface water in receiving waters	if significant, use percolation basins or injection wells as part of the ground-water control strategy
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	contaminated soil resulting from excavation can become contaminated fugitive dusts	see soils/geology below
Soils/Geology	excavated matter may contain hazardous material and may contaminate soils	contain excavated material and handle as contaminated matter
Biota	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	see surface-water quality above
	drainage ditch may present hazard to wildlife which might fall into it	cover the drainage ditch
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off the site and expose public	see air quality and surface-water quality above
	if riparian zone develops, a contaminant pathway to human food chain may be established	prevent vegetative growth with herbicides
	drainage ditch may present hazard to public who might fall into it	secure area from public
	standing water in drainage ditch can be an insect breeding area	use covers and/or oil film

TABLE 5.3a. Leachate Collection and Treatment: Liners—Under-Waste Grouting

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff containing drill cuttings may carry contaminated sediments to receiving waters	see soils/geology below
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	contaminated soil resulting from drill cuttings can become contaminated fugitive dusts	see soils/geology below
Soils/Geology	drill cuttings may contain hazardous material and may contaminate soils	contain excavated material and handle as contaminated matter
Biota	fugitive dust (contaminated or uncontaminated) from activity can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from activity can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off the site and expose public	see air quality and surface-water quality above
	drilling can encounter pyrophoric or explosive matter, which could result in a significant release and public exposure	establish and enforce drilling procedures

TABLE 5.3b. Leachate Collection and Treatment: Liners—Bentonite Slurry

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	handling of dry bentonite powder can result in fugitive dust	handle bentonite as a slurry

6.0 GAS-MIGRATION CONTROLS

Gas-migration controls are used to control the lateral movement of flammable and volatile toxic gases and to control emissions to the atmosphere of volatile toxic compounds from an uncontrolled hazardous-waste site.

6.1 PIPE VENTS

Pipe vents include vertical or lateral perforated pipe installed in and around the landfill. Possible effects of the use of pipe vents are summarized in Table 6.1 and described in the good engineering practice table, Table 6.1a, at the end of this section.

Installing vertical pipes in the landfill involves drilling through the waste site. Drilling through hazardous-waste sites is risky. Methane in the ground can become diluted to explosive limits during the drilling and installation operations. Thus, explosion and fire are potential adverse effects resulting from use of this technology. This effect should be addressed when developing drilling plans.

When a pipe vent system is successfully installed, methane and other products of anaerobic decomposition are released to the atmosphere, together with vapors of any of the toxic materials that may be present. The release of these toxic vapors presents a small but not-insignificant potential health and safety hazard to humans and biota. The release of the methane and other products of anaerobic decomposition could create a local degradation in air quality, because anaerobic decomposition produces gases other than methane, some of which are extremely offensive. The release of these offensive gases can be prevented only by using gas-collection and -treatment or -recovery measures (see Sections 6.4, 6.5, and 6.6 of EPA 1982).

Surface soils may be disrupted by construction of the venting system. Loose soils can become fugitive dusts and contaminate the air locally or can be carried by surface runoff to receiving waters, where they contribute to the sediment load. Release of uncontaminated soils as fugitive dusts can be prevented by water spraying or other measures (see Addendum 1). Runoff containing uncontaminated soils can be prevented using surface-water diversion and collection measures together with revegetation (see

TABLE 6.1. Effects of Gas-Migration Controls: Pipe Vents

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● HPR	—	● NPR	● HPR	● HPR	● HPR	● NPI
—	—	● NSR	—	● HPR	—	—	—	—
—	—	—	—	● NSR	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Sections 3.3 and 3.4 of EPA 1982). However, if the surface soils contain drill cuttings or excavated materials, fugitive dusts and sediments may be contaminated with the hazardous matter. Contamination of fugitive dusts and runoff sediments can be prevented by treating excavated material as hazardous matter and disposing of it accordingly.

It should be noted that each pipe vent passing through a surface cap represents a possible breach of that cap. Vent openings, therefore, should be local high spots. Even if the site is not capped, vents represent a possible pathway for water to enter the waste area directly.

Removing the gases from the site may cause subsidence and disrupt capping or surface contouring, thereby interfering with other remedial measures. This effect can be precluded by recognizing the risk, inspecting the site periodically to see that subsidence has not occurred, and taking action (recontouring) if it has occurred.

If the pipe vents are being used with forced ventilation, there is the additional long-term commitment of electrical energy to provide the pumping. This is an unavoidable aspect of the use of forced ventilation.

6.2 TRENCH VENTS

Trench vents provide a barrier against lateral migration of gases. These are deep, narrow, gravel-filled trenches spanning part or all of the perimeter of the waste site. Gases migrate into the trenches from which they are collected. Possible effects of the use of trench vents are summarized in Table 6.2 and described in the good engineering practice table, Table 6.2a, at the end of this section.

During excavation of trench vents, methane concentrations may be diluted to explosive concentrations. Thus, a potential hazard to the health and safety of humans and neighboring biota exists because of the potential for fire or explosion. This unavoidable effect should be considered when preparing excavation plans. In some cases, trench vents may be used with an air blanket pumped into the vent (EPA 1982). Again, this can dilute methane concentrations to explosive levels causing a long-term hazard for explosion.

TABLE 6.2. Effects of Gas-Migration Controls: Trench Vents

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● NSR	—	● NSR	● HPR	● NPI	—	● NPI
—	—	● HPR	—	● HPR	—	○ HPR	—	—
—	—	—	—	—	—	● NPR	● HPR	—
—	—	—	—	—	—	—	● NPR	—

● = Highly Probable

○ = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

R = Reversible (or mitigable)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

If an air blanket is used or if the trench is pumped to remove the gases, a long-term commitment of energy resources is implied. This is an unavoidable aspect of the use of forced ventilation.

During the construction of trench vents, surface soils can be disturbed, which may lead to fugitive-dust emissions and contribute to sediment loading in receiving waters from surface runoff. If the excavated soils contain hazardous materials, the fugitive dust and sediments can be contaminated. The dust and sediments can further contaminate local soils and represent a hazard to humans and neighboring biota. The spread of contamination in this way and the associated hazards can be mitigated by treating contaminated excavated material as hazardous matter. Emissions of uncontaminated fugitive dust can be prevented by water spraying and other measures (see Addendum 1). Increased sediment loading of receiving waters can be prevented by using surface-water diversion and collection measures together with revegetation (see Sections 3.3 and 3.4 of EPA 1982).

Additionally, trenches venting to the atmosphere can emit hazardous or noxious chemicals to the air, resulting in a degradation of local air quality and exposure of the public and biota. Such degradation can be prevented by the use of collection and treatment facilities (see Section 6.4 of EPA 1982).

Trench vents potentially can affect ground water as well as control gas migration. Open trenches provide a direct pathway for recharge from the surface to the waste. This is an unavoidable aspect of the use of trench vents; hydrologic consequences of this measure should be considered during the alternative selection process. Additionally, release of the gases could affect the integrity of capping and other surface-water controls; this is unavoidable but can be mitigated in part by periodically inspecting the site and, if subsidence has occurred, recontouring.

Open trenches represent a potential hazard to wildlife and people who might fall into the trench. The hazard to people can be mitigated through fencing and other security measures to prevent the public from entering the site. The hazard to biota cannot be avoided when using open trenches.

6.3 GAS BARRIERS

Gas barriers are used to prevent the vertical or lateral migration of gases and to assist in gas collection. The barriers usually are used together with other methods. Possible effects of the use of gas barriers are summarized in Table 6.3 and described in the good engineering practice table, Table 6.3a, at the end of this section.

TABLE 6.3. Effects of Gas-Migration Controls: Gas Barriers

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	●NSR	○NPR	●NSR	—	●NSR	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Creating gas barriers involves construction activities that disrupt surface soils. This can cause fugitive dust to be raised and sediments to be carried to receiving surface waters by overland runoff. The fugitive dusts or sediments could cause negative effects on the resident biota. Fugitive emissions can be controlled by water spraying or other methods (see Addendum 1). Transport of sediment by overland runoff can be prevented by using surface-water diversion and collection methods together with revegetation (see Sections 3.3 and 3.4 of EPA 1982).

Because gas barriers will also be barriers to surface-water percolation, they will affect runoff and the amount of water discharged to surface waters. This effect can be mitigated, if necessary, through the use of surface-water controls, holding ponds, and percolation beds (see Section 3.4 of EPA 1982).

6.4 GAS-COLLECTION SYSTEMS

Gas-collection systems gather the gas collected in trenches or pipe vents and carry it to a point for treatment or for use. Possible effects of the use of gas-collection systems are summarized in Table 6.4 and described in the good engineering practice table, Table 6.4a, at the end of this section.

The only direct effects of gas-collection systems are the energy commitment and noise associated with pumping operations. Neither of these can be avoided completely if gas collectors are used. However, the noise effects of pumping can be reduced by enclosing the pumps and/or operating the pumps on a daily cycle such that public annoyance is minimized.

The installation of gas-collection systems involves construction activities, which can raise fugitive dusts; these dusts can affect resident biota. The effects of fugitive dusts can be minimized by water spraying and other measures (see Addendum 1). Disturbed areas can contribute sediments to surface runoff, which will be discharged to receiving waters and may affect biota inhabiting those waters. These effects can be reduced by the use of surface-water diversion and collection measures together with revegetation (see Sections 3.3 and 3.4 of EPA 1982).

TABLE 6.4. Effects of Gas-Migration Controls: Gas-Collection Systems

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● NSR	—	● NPI ● NSR	—	● NSR	—	● NPI
—	—	—	—	—	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

6.5 GAS TREATMENT

Gases that are collected from an uncontrolled hazardous-waste site can be treated via sorption or thermal oxidation. In thermal oxidation, the gases are oxidized either in a self-sustaining manner through flares or through the use of afterburners. In methods of treatment using sorption, the gases are

TABLE 6.5. Effects of Gas-Migration Controls: Gas Treatment

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Flares	—	—	—	—	⊙ NPI	—	—	—	—
Afterburners	—	—	⊙ NPR	—	⊙ NPR	—	—	—	● NPI
Sorption									
Once-through	⊙ HPR	—	⊙ HPR	—	—	⊙ HPR	—	—	—
Regenerated	⊙ HPR	—	⊙ HPR	—	⊙ HSR	⊙ HPR	—	—	● NPI

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

⊙ = Probable

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○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

sorbed on activated carbon either on a once-through basis or with regeneration of the activated carbon. Possible effects of the use of gas-treatment methods are summarized in Table 6.5 and described in the good engineering practice tables, Tables 6.5a-c, at the end of this section.

Flares used to oxidize methane and noxious gases can degrade local air quality because these create noxious and corrosive combustion products. The effects to air quality are irremediable if flares are used.

Afterburners imply a long-term, irremediable commitment of fuel to oxidize the collected gases. The combustion products can be noxious or corrosive and, therefore, can degrade air quality. The latter effect can be remedied by the use of some sort of scrubbing system. However, the process waters from this scrubbing system, if discharged to receiving waters, may degrade surface-water quality and adversely affect biota inhabiting these surface waters. This can be mitigated by treating scrubbing waters before discharge.

Once-through sorption of noxious gases on activated carbon leaves the problem of disposal of the spent carbon. Because the carbon contains the hazardous material, it can degrade the soil and surface- and ground-water quality if it is not properly disposed of (that is, in a RCRA site).

If the carbon is regenerated, the out gases must be collected and treated either by flare or via afterburners. Either method then leads to the potential effects associated with the final treatment. Activated carbon does not retain its effectiveness for an indefinite number of regeneration cycles, so when it is spent, it must be disposed of. If improperly disposed of, it can contaminate soils and degrade surface- or ground-water quality. Accordingly, spent carbon from a regeneration cycle should also be handled as hazardous material.

6.6 GAS RECOVERY

Gases extracted from an uncontrolled hazardous-waste site may be recovered and used for their thermal value. Possible effects of the recovery of gases are summarized in Table 6.6 and described in the good engineering practice table, Table 6.6a, at the end of this section.

TABLE 6.6. Effects of Gas-Migration Controls: Gas Recovery

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	—	—	● NPI	—	—	—	—

● = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

These gases usually are contaminated with hazardous and noxious vapors; they would be 'sweetened' before use. The waste stream of the sweetening process will include noxious gases that also must be disposed of, most probably through the use of flares because of the energy commitment of after-burners. Accordingly, flaring these gases can reduce air quality.

TABLE 6.1a. Gas-Migration Controls: Pipe Vents

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	this measure may interfere with effectiveness of cap or surface contouring leading to ground-water contamination	consider possible interactions between measures; inspect and repair as required
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff from soils containing drill cuttings can carry contaminated sediments to receiving waters	see soils/geology below
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	fugitive dusts from soils containing drill cuttings can be contaminated	see soils/geology below
	release of toxic vapors can degrade air quality	use gas-collection and -treatment (or -recovery) measures (see EPA 1982, Sections 6.4-6.6)
	release of anaerobic decomposition products can degrade air quality	use gas-collection and -treatment (or -recovery) measures (see EPA 1982, Sections 6.4-6.6)
Soils/Geology	drill cuttings may contaminate soils	contain drill cuttings; handle as hazardous matter
Biota	release of toxic vapors may affect resident biota	see air quality above
	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from activity can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from activities can carry hazardous material off site	see air quality and surface-water quality above
	release of toxic vapors may affect public health	see air quality above
	during drilling, methane may be diluted to explosive limit, presenting risk of explosion	consider this possibility when developing drilling plan
Resource Commitment	if used with forced ventilation, a long-range commitment of electrical energy is implied	none; unavoidable effect of this technology

TABLE 6.2a. Gas-Migration Controls: Trench Vents

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	this measure may interfere with effectiveness of cap or surface contouring leading to ground-water contamination	consider possible interactions between measures; inspect and repair as required
	this measure may interfere with hydrologic control measures	consider possible interactions between measures
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff from soils containing excavated matter can carry contaminated sediments to receiving waters	see soils/geology below
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	fugitive dusts from soils containing excavated matter can be contaminated	see soils/geology below
	release of toxic vapors can degrade air quality	use gas-collection and -treatment measures (see EPA 1982, Section 6.4)
	release of anaerobic decomposition products can degrade air quality	use gas-collection and -treatment measures (see EPA 1982, Sections 6.4)
Soils/Geology	excavated matter may contaminate soils	contain excavated matter; handle as hazardous matter
Biota	release of toxic vapors may affect resident biota	see air quality above
	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from activity can affect aquatic biota	see surface-water quality above
	open trenches represent a potential hazard to wildlife which might fall into them	none; unavoidable aspect of open trenches
Public Health or Safety	contaminated fugitive dust or contaminated sediment from activities can carry hazardous material offsite	see air quality and surface-water quality above
	release of toxic vapors may affect public health	see air quality above
	during excavating, methane may be diluted to explosive limit, presenting risk of explosion	consider this possibility when developing excavating plan
	open trenches represent a potential hazard for the public who might fall into them	control access
Resource Commitment	if used with an air blanket or if trench is pumped, a long-range commitment of electrical energy is implied	none; unavoidable effect of this technology

TABLE 6.3a. Gas-Migration Controls: Gas Barriers

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Surface-Water Quality	changes in percolation of surface water can result in increased discharge to receiving waters	incorporate surface-water controls, holding ponds, and percolation basins as appropriate (see EPA 1982, Section 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
Biota	fugitive dust from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment from activity can affect aquatic biota	see surface-water quality above

TABLE 6.4a. Gas-Migration Controls: Gas-Collection Systems

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	pumping operations will generate noise	none; unavoidable effect of this technology; if possible operate on cycle to minimize effect
Biota	fugitive dust from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment from activity can affect aquatic biota	see surface-water quality above
Resource Commitment	pumping operations imply a commitment of electrical energy	none; unavoidable effect of this technology

TABLE 6.5a. Gas-Migration Controls: Gas Treatment—Flares

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	noxious or corrosive combustion products may degrade air quality	none; unavoidable

TABLE 6.5b. Gas-Migration Controls: Gas Treatment—Afterburners

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Surface-Water Quality	scrubber waste water can degrade quality of receiving waters	treat scrubber waste water before discharge
Air Quality	noxious or corrosive combustion products may degrade air quality	use scrubber (see surface-water quality above)
Resource Commitment	long-term commitment to supply fuel to oxidize collected gases	none; unavoidable aspect of this technology

TABLE 6.5c. Gas-Migration Controls: Gas Treatment—Carbon Sorption

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	disposal of spent carbon can result in ground-water contamination	dispose of in a RCRA-approved site
Surface-Water Quality	disposal of spent carbon can result in surface-water contamination	dispose of in a RCRA-approved site
Air Quality	regeneration of carbon releases toxic vapors which can degrade air quality	use flare or afterburner (see EPA 1982, Section 6.5)
Soils/Geology	disposal of spent carbon can result in soil contamination	dispose of in a RCRA-approved site

TABLE 6.6a. Gas-Migration Controls: Gas Recovery

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	flaring of extracted noxious gases can degrade air quality	none; unavoidable

7.0 DIRECT-TREATMENT METHODS

Direct treatment methods involve control of the pollutant source, rather than control of the transport medium. Direct treatment involves one or more of the following:

- physical removal together with disposal in a more suitable location,
- physical removal followed by stabilization or destruction, or
- in situ treatment.

7.1 EXCAVATION

Excavation involves the removal for further treatment of the hazardous waste from an uncontrolled site. The potential effects associated with excavation are summarized in Table 7.1 and described in the good engineering practice table, Table 7.1a, at the end of this section.

When excavating dry matter, the construction-type activities used can cause noise and fugitive dust. The noise is an irremediable effect; it can be mitigated in part by operating only during normal daylight working hours. Fugitive dust may be contaminated by the wastes and spread hazardous matter to other areas if not controlled. Contaminated or uncontaminated fugitive dust can affect resident biota. Uncontaminated fugitive dusts can be controlled by water spraying and other methods. Because sprinkling is only about 50% effective, highly contaminated fugitive dust may have to be controlled by other methods. For instance, an enclosure could be erected around the site during the excavation activities. (See Addendum 1.)

The construction activities will disturb the surface; therefore, contaminated or uncontaminated sediments may be contributed to receiving water via runoff. These sediments can adversely affect aquatic biota. Surface-water diversion and collection controls and revegetation can be used to prevent the degradation of surface-water quality (see Sections 3.3 and 3.4 of EPA 1982).

TABLE 7.1. Direct-Treatment Methods: Excavation

	Ground-Water		Surface-Water		Air Quality	Soils/Geology	Biota	Public Health/Safety	Resource Commitments
	Quality	Movement/Quantity	Quality	Movement/Quantity					
Dry-Matter	—	—	⊙ HPR	—	⊙ NSR	⊙ HPR	⊙ HPR	⊙ NSI	—
	—	—	⊙ NSR	—	⊙ HPR	—	⊙ NSR	⊙ HSR	—
	—	—	—	—	⊙ NSI	—	—	⊙ HPR	—
Wet-Matter/Sludge	⊙ HPR	—	⊙ HPR	—	⊙ NSI	⊙ HPR	⊙ HPR	⊙ NSI	—
	—	—	—	—	⊙ HPI	—	⊙ NSR	⊙ HPR	—
	—	—	—	—	⊙ HPR	—	—	⊙ HSR	—

● = Highly Probable

⊙ = Probable

N = Nuisance

H = Hazardous

S = Short-term (construction phase only)

R = Reversible (or mitigable)

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Additional adverse effects that the exhumation of dry matter can cause include releases to the atmosphere of evaporating materials (including potentially hazardous materials) and the potential for fire and/or explosion. Evaporation of volatiles is an unavoidable aspect of waste excavation. Excavation activities can release explosive concentrations of waste materials or expose pyrophoric matter. Fire or explosion would be likely to release hazardous matter beyond the confines of the waste site, thereby contaminating soils and forming a health and safety hazard for humans and biota. The potential for exposing explosive or pyrophoric matter should be considered when preparing the excavation plan.

When excavating wet matter, liquids and sludges must be removed from lagoons or holding basins. When this wet matter is removed, waters will seep from the spoils. These waters will be contaminated with some of the hazardous material and can, in turn, contaminate surface water, ground water, or soils.

Prevention of the release of dewatering liquids is the appropriate mitigative action; these waters should be contained and held for treatment as hazardous matter. In addition, the process of excavating the sludges can cause additional breaches of the containment, allowing contaminated matter to reach ground water. This effect is mitigated by taking care during the excavation process, and excavating sufficient material to ensure that all contaminated matter has been removed.

During the handling of the hazardous material, wet or dry, the potential for spills exists. Although spills should be avoided through careful handling of the contaminated matter, their potential should be recognized and procedures for identifying and removing these should be implemented.

Other effects inherent to the handling and/or the disposal of the hazardous waste are caused by the traffic associated with off-site removal. This traffic creates a short-term irremediable noise effect and forms a potential traffic safety hazard. The transport of hazardous matter to disposal sites may result in releases. A fraction of the material hauled can be expected to be released as contaminated fugitive dust. This can be minimized by hauling the excavated matter in containers. An accident could result in a major release of material.

7.2 HYDRAULIC DREDGING

Hydraulic dredging can be used to physically remove contaminated material. The potential effects associated with hydraulic dredging are summarized in Table 7.2 and described in the good engineering practice table, Table 7.2a, at the end of this section.

Using this direct method, leaks from pumps and/or conduits (hose or piping) can contaminate soils or surface water. This effect can be avoided by observing the removal process carefully and treating any such releases as spills of hazardous material. In addition, runoff material from dredged matter can contaminate soils, surface water, or ground water. This contamination can be prevented by containing dredge-spoil runoff and treating it as hazardous matter. The hydraulic-dredging process may damage the existing confinement, resulting in releases to ground water. This effect can be prevented by removing enough material to ensure that no contaminated matter remains.

Construction-like activities will disturb surface soils. Fugitive dusts will be raised; if these soils have been contaminated by spills or leaks, the fugitive dusts may be contaminated. Fugitive dusts can adversely affect resident biota; contaminated fugitive dusts can be carried off site and affect the public. Fugitive dust emissions can be controlled by various methods (see Addendum 1.1).

TABLE 7.2. Direct-Treatment Methods: Hydraulic Dredging

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● HPR	—	● NSR ● HSI ● HPR	● HPR	● HPR ● NSR	● NSI ● HPR	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

○ = Probable

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○ = Improbable

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The disturbed soils can result in the release of sediment to receiving waters. If the soil is contaminated, the sediments may be contaminated. These sediments can adversely affect aquatic biota and public health. Surface-water diversion and collection controls and revegetation can be used to prevent the degradation of surface-water quality (see Sections 3.3 and 3.4 of EPA 1982).

If the dredged material is to be transported off site, there will be noise, fugitive dust, and traffic hazards associated with the hauling activity. These short-term effects cannot be prevented totally, but can be minimized by confining operations to normal daylight working hours.

7.3 LAND DISPOSAL

Land disposal includes disposal of the hazardous matter in secure landfills, surface impoundments, and land application. Land-disposal activities are regulated under rules promulgated under the Resource Conservation and Recovery Act (RCRA). The potential effects associated with land disposal are summarized in Table 7.3 and described in the good engineering practice tables, Tables 7.3a-c, at the end of this section.

Landfills and surface impoundments do not destroy or treat wastes. The use of these techniques primarily delays and dilutes the release although some natural degradation (chemical, physical, and biological) may occur depending on the characteristics of the material. Consequently, the use of these technologies may eventually create all the environmental effects that prompted the remedial action in the first place; however, if the site is properly chosen in accord with RCRA rules, the probability and magnitude of these effects can be expected to be reduced greatly.

Landfilling or the use of surface impoundments commits the land to use as a disposal site for an indefinite period. During the construction and open phase of the landfill or controlled surface impoundment facility, construction activities will raise fugitive dust. Emissions of fugitive dust can be reduced by water spraying and other methods (see Addendum 1). Also, because the surface cover will be disturbed, sediment carried by runoff may contaminate receiving waters. This effect can be prevented by use of runoff controls and sedimentation basins. Land application, or land farming, as it is sometimes called, involves the application of the waste matter to surface soils where microbial action can destroy it. Because wastes are applied directly to the surface, contaminant vapors can pollute the air

TABLE 7.3. Direct-Treatment Methods: Land Disposal

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Land Fill	● HPR —	— —	● NSR ● HPR	— —	● NSR ● HSR	● HPR —	● NSR ● HPR	● HPR —	● NPI —
Surface Impoundment	● HPR —	— —	● HPR ● NSR	— —	● HPI ● NSR	● HPR —	● HPR ● NSR	● HPR —	● NPI —
Land Application	● HPR	—	● HPR	—	● HPR	● HPR	● HPR	—	● NPI

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and create an offensive odor in the surrounding area. Using this method, surface soils are highly disturbed, so they can form a source of fugitive dusts, both contaminated and uncontaminated. These air pollution effects are integral to the land-application method and cannot be avoided or mitigated within this method. The release of fugitive dusts can be minimized by properly choosing weather conditions for tilling and maintaining moist soil conditions.

Because the surface soils are disturbed, runoff controls and sedimentation basins (see Section 3.4 of EPA 1982) will be required to prevent the transport of contaminated sediments to receiving waters by overland flow. Since wastes are applied directly to the surface, contamination of ground water is of concern. Ground-water contamination can be prevented only by careful design of the land application to ensure that 1) the design does not overwhelm the capacity of the land to destroy the material and 2) the process is monitored to determine that it is working as designed and no migration off site is occurring. Particular design attention should be given to abnormal weather conditions that may affect recharge or microbial activity and, therefore, may lead to contamination of ground water. Caution is advised in the cultivation of feed or food crops in soils being used or which have been used for land application to avoid plant uptake and the bioaccumulation of hazardous materials which may be passed through the food chain.

7.4 SOLIDIFICATION

Solidification is a process of consolidating the hazardous-waste material before secure disposal, either on site or off. It is not a disposal alternative in itself, but rather a component in an alternative. The potential effects associated with solidification are summarized in Table 7.4 and described in the good engineering practice tables, Tables 7.4a-f, at the end of this section.

Solidifying the waste using cement-based, lime-based, or self-cementing solidification processes can raise fugitive dusts during the handling of the solidifying material. This is probably irremediable, because the materials are finely divided and must be handled when dry. In addition, because the

TABLE 7.4. Direct-Treatment Methods: Solidification

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Cement-Based	O HPR	—	—	—	⊙ HSR ⊙ NSI	⊙ HPR	—	—	—
Lime-Based	—	—	—	—	⊙ HSR ⊙ NSI	⊙ HPR	—	—	—
Thermoplastic-Based	—	—	—	—	⊙ HSR	⊙ HPR	—	—	● NSI
Organic Polymer-Based	⊙ HSR	—	⊙ HSR	—	—	⊙ HPR	—	—	—
Self-Cementing	—	—	—	—	⊙ HSR ⊙ NSI	⊙ HPR	—	—	● NSI
Classification	—	—	—	—	⊙ HSR	⊙ HPR	—	—	● NSI

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hazardous material may need to be dried in the cement-based, lime-based, thermoplastic-based, self-cementing, and glassification processes, hazardous matter may be emitted during the drying process, either as fugitive dusts or as vapors.

Waste materials such as fly ash, bottom ash and slag, furnace slag, and incinerator residue are commonly used materials for solidifying liquid or sludge matter in a pit or lagoon. As noted in Section 3.1 of this guide, these materials commonly contain heavy metals and other objectionable matter which can contribute to contamination. Additionally, these materials can change ground-water chemistry so as to mobilize components that may have been fixed in the waste. This potential for ground-water contamination can be reduced by characterization of soil, waste, and combustion-residue chemistry to determine if the potential for a problem exists.

7.5 ENCAPSULATION

Encapsulation is a process by which the hazardous matter is physically enclosed within a container. The potential effects associated with encapsulation are summarized in Table 7.5 and described in the good engineering practice table, Table 7.5a, at the end of this section.

Potential adverse effects are the emissions and spills occurring during the handling process. The emissions of fugitive dust or vapors are probably irreducible. Spills should be taken into consideration and treated as part of the cleanup activity.

As part of the encapsulation process, the containers will be fused. This process involves the commitment of energy.

TABLE 7.5. Direct-Treatment Methods: Encapsulation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	—	—	⊙ HSI	⊙ HPR	—	—	● NSI

● = Highly Probable

⊙ = Probable

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S = Short-term (construction phase only)

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NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

7.6 IN SITU TREATMENT

For in situ treatment, wastes are treated in place or removed with minimal soil disruption. In situ treatment processes include surface solution mining, neutralization/detoxification, and microbial degradation. The potential effects associated with in situ treatment are summarized in Table 7.6 and described in the good engineering practice tables, Tables 7.6a-c, at the end of this section.

7.6.1 In Situ Treatment—Solution Mining

In solution mining, the wastes are removed by flushing them out of the soil using water, acidic or basic solutions, or complexing or chelating agents. The leachate thus generated is collected and removed for treatment.

TABLE 7.6.1 Direct-Treatment Methods: In-Situ Treatment—Solution Mining

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Water	⊙ HSR	—	—	—	—	—	—	—	—
Acid	⊙ HSR	—	—	—	⊙ NSI	—	⊙ NSI	—	—
	—	—	—	—	⊙ HSI	—	—	—	—
Alkali	⊙ HSR	—	—	—	⊙ NSI	—	⊙ NSI	—	—
	—	—	—	—	⊙ HSI	—	—	—	—
Complexing/ Chelating	⊙ HSR	—	—	—	⊙ NSI	—	⊙ NSI	—	—
	—	—	—	—	⊙ HSI	—	—	—	—

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R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Contamination of ground water by any of the possible elutriates, is a major concern. The use of solution mining contains as an article of faith that the leachate will be collected. Because inhomogeneities or uncertainties in the hydrologic system can allow leachate to pass uncollected, ground-water contamination is a real concern. This effect is remediable, but only via ground-water treatment (see Section 4 of EPA 1982) if it occurs.

Releases of the elutriating agent, if other than water, also can cause atmospheric pollution through vaporization. Other sources of air pollution are reaction products occurring as a result of uncontrolled reactions between the elutriate and the waste. These sources of air pollution are integral to the method and the reagents involved and cannot be mitigated.

Finally, some chelating agents are themselves somewhat toxic and may damage existing biota. Once again, the effects of these solvents are integral to the method used and probably cannot be mitigated.

7.6.2 In Situ Treatment—Neutralization/Detoxification

Neutralization/detoxification is the technique of applying or injecting into the uncontrolled waste disposal site a substance that immobilizes or destroys the contaminant. This method can produce a leachate that may contaminate ground water with the hazardous material or with the reagent itself. In addition, immobilized material could be remobilized by subsequent changes in soil chemistry. (For instance, an oxidation by bacteria causing the remobilization of heavy metal ions.) If such leachate reaches the ground water, it would be a potential hazard for human health and safety and could be remedied only via ground-water treatment methods. Monitoring ground-water quality to detect possible contamination should be an integral part of this method.

The reagents used to neutralize and/or detoxify wastes may be volatile and form air pollutants. Uncontrolled or unexpected reaction between the reagents and the waste matter may release hazardous matter to the atmosphere. The rate of release will be controlled in part by ambient surface conditions. Also, neutralization and detoxification reagents may be toxic to local biota. The effects of this toxicity are inherent to the method and are probably not otherwise mitigable, but should be recognized.

TABLE 7.6.2 Direct-Treatment Methods: In-Situ Treatment—Neutralization/Detoxification

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HSR	—	—	● HSI	—	—	● NSI	—	—
● NSR	—	—	● NSI	—	—	—	—	—
● HPR	—	—	—	—	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

O = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

7.6.3 In Situ Treatment—Microbial Degradation

Microbial degradation involves an enhancement of natural biodegradation by seeding the site with appropriate bacteria or other microorganisms, adding nutrients or chemical buffers, and aerating.

Because microbial degradation is a slow process, the waste matter may leach out of the soil and contaminate ground water before degradation is complete. This effect, if it occurs, is remediable only via ground-water cleanup (see Section 4.0 of EPA 1982). Nutrients added to assist the microbial degradation process can themselves contaminate ground water with nontoxic contaminants. The latter effect is also remediable only through ground-water cleanup.

TABLE 7.6.3 Direct-Treatment Methods: In-Situ Treatment—Microbial Degradation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HSR	—	—	—	—	—	—	—	—
● NPR	—	—	—	—	—	—	—	—

● = Highly Probable ○ = Improbable
 N = Nuisance — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

7.7 OTHER DIRECT TREATMENT METHODS

Other direct treatment methods include molten-salt destruction and plasma reduction processes. In the molten-salt process, the contaminated material is injected into a molten salt where it is destroyed. In plasma reduction, the material is injected into a plasma (an electrical discharge in a gas) where the contaminants are destroyed. The potential effects associated with other direct treatment methods are summarized in Table 7.7 and described in the good engineering practice table, Table 7.7a, at the end of this section.

For each of these processes, the major effect is the commitment of energy resources, because both methods are very energy intensive. This energy commitment is unavoidable.

Emissions of the hazardous material may occur during the handling and injection processes and spills may occur during the handling process. Emissions of the hazardous materials are probably irremediable. Spills should be anticipated and cleaned up before the site is deemed to have been restored.

TABLE 7.7 Direct-Treatment Methods: Others

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Molten Salt	—	—	—	—	● HSI	● HPR	—	—	● NSI
Plasma Reduction	—	—	—	—	● HSI	● HPR	—	—	● NSI

● = Highly Probable ○ = Probable
 N = Nuisance H = Hazardous
 S = Short-term (construction phase only)
 R = Reversible (or mitigable)

○ = Improbable
 — = No significant effects predicted
 P = Persistent (beyond construction phase)
 I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

TABLE 7.1a. Direct-Treatment Methods: Excavation

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	dewatering off waters can contaminate ground waters	contain dewatering liquids; treat as hazardous matter
	excavation process can further breach original containment allowing contaminants to reach ground water	excavation process should remove enough matter to ensure that all contaminated material is removed
Surface-Water Quality	runoff from soils disturbed during excavation activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	dewatering off waters can contaminate surface waters	see ground-water quality above
Air Quality	excavation activities can result in release of fugitive dusts	fugitive dust control (see Addendum 1)
	excavation of contaminated matter can contaminate soils, which can become contaminated fugitive dusts	control contaminated fugitive dust (see Addendum 1)
	construction-like activities will produce noise	schedule activities to minimize effects
	evaporating hazardous matter can reduce air quality	none; unavoidable aspect of waste exhumation
	off-site haulage of exhumed matter can result in airborne releases	haul material in closed containers or covered trucks
Soils/Geology	spills of exhumed matter can contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
	exhumation of pyrophoric or flammable material can result in fire or explosion which can contaminate soils beyond original extent	see public health or safety below
	dewatering off waters can contaminate soils	see ground-water quality above
Biota	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation difficult
	sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off site	see air quality and surface-water quality above
	exhumation of flammable, explosive, or pyrophoric matter could result in fire or explosion	establish and enforce operating procedures that include this possibility
	haulage of excavated matter for disposal can present traffic safety hazard	schedule and route hauling to minimize traffic risks
	accident involving truck hauling exhumed matter can represent major release	include possibility of such an accident in contingency planning; route hauling to minimize effect

TABLE 7.2a. Direct-Treatment Methods: Hydraulic Dredging

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	dewatering off waters can contaminate ground waters	contain dewatering liquids; treat as hazardous matter
	dredging process can further breach original containment allowing contaminants to reach ground water	dredging process should remove enough matter to ensure that all contaminated material is removed
Surface-Water Quality	dewatering off waters can contaminate surface waters	see ground-water quality above
Air Quality	dredging activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	spills or leaks of contaminated matter can contaminate soils, which can become contaminated fugitive dusts	control contaminated fugitive dust (see Addendum 1)
	evaporating hazardous matter can reduce air quality	none; unavoidable aspect of waste exhumation
	off-site haulage of exhumed matter can result in airborne releases	haul material in closed containers or covered trucks
Soils/Geology	spills of exhumed matter or leaks from pumps and lines can contaminate soils	spills and leaks should be expected and spill cleanup incorporated in operating plan
	dewatering off waters can contaminate soils	see ground-water quality
Biota	fugitive dust (contaminated or uncontaminated) from dredging can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from dredging can affect aquatic biota	see surface-water quality above
Public Health or Safety	contaminated fugitive dust or contaminated sediment from dredging activities can carry hazardous material off site	see air quality and surface-water quality above
	haulage of excavated matter can result in traffic noise	schedule and route hauling to minimize traffic risks
	haulage of excavated matter for disposal can present traffic safety hazard	schedule and route hauling to minimize traffic risks
	accident involving truck hauling exhumed matter can represent major release	include possibility of such an accident in contingency planning; route hauling to minimize effect

TABLE 7.3a. Direct-Treatment Methods: Land Disposal—Landfilling

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	leak of material can contaminate ground water	use a RCRA-approved site
Surface-Water Quality	runoff from soils disturbed during excavation activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	release of material can contaminate surface water	use a RCRA-approved site
Air Quality	landfilling activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	evaporating hazardous matter can reduce air quality	use a RCRA-approved site
Soils/Geology	releases from landfill can contaminate soils	use a RCRA-approved site
	release of matter from landfill can expose biota to hazardous waste	use a RCRA-approved site
Biota	fugitive dust from landfilling can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment from landfilling can affect aquatic biota	see surface-water quality above
Public Health or Safety	release of matter from landfill can expose public to hazardous matter	use a RCRA-approved site
Resource Commitment	land is committed to use as hazardous waste disposal site for an indefinite period	none; unavoidable aspect of this technology

TABLE 7.3b. Direct-Treatment Methods: Land Disposal—Surface Impoundment

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	leak of material can contaminate ground water	use a RCRA-approved site
Surface-Water Quality	runoff from disturbed soils during excavation activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	release of material can contaminate surface water	use a RCRA-approved site
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	evaporating hazardous matter can reduce air quality	use a RCRA-approved site
Soils/Geology	releases from impoundment can contaminate soils	use a RCRA-approved site
	release of material from impoundment can expose biota to hazardous substances	use a RCRA-approved site
Biota	fugitive dust from construction can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment from construction can affect aquatic biota	see surface-water quality above
Public Health or Safety	release of matter can expose public to hazardous substances	use a RCRA-approved site
Resource Commitment	land is committed to use as hazardous waste disposal site for an indefinite period	none; unavoidable aspect of this technology

TABLE 7.3c. Direct-Treatment Methods: Land Disposal—Land Application

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	material can contaminate ground water	design carefully; establish procedures for monitoring; consider possibility of abnormal weather conditions
Surface-Water Quality	runoff from highly disturbed soils can carry contaminated sediment to receiving waters	incorporate surface-collection measures as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Air Quality	disturbed soils can be source of contaminated fugitive dusts	maintain moist soil conditions; establish and enforce procedures for scheduling tilling activities
	evaporating hazardous matter can reduce air quality	none; unavoidable aspect of this technology
Soils/Geology	soils will be contaminated with hazardous matter	none; unavoidable aspect of this technology
Biota	inadvertant release can expose biota to hazardous matter	prevention: see ground-water quality, surface-water quality, and air quality above
Public Health or Safety	release of matter can expose public to hazardous matter	prevention: see ground-water quality, surface-water quality, and air quality above
	if vegetation grown on soil enters food chain, it can expose public to hazardous matter	establish and enforce procedures to ensure that vegetation does not enter food chain
Resource Commitment	land is committed to use as hazardous waste disposal site for an indefinite period	none; unavoidable aspect of this technology

TABLE 7.4a. Direct-Treatment Methods: Solidification—Cement-Based Methods

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	use of combustion waste matter for solidifying contents of pit or lagoon can result in ground-water contamination	characterize soil, waste, and combustion chemistry to determine whether this will be a problem
Air Quality	handling of solidifying material can result in release of fugitive dusts	none; unavoidable
	drying process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan

TABLE 7.4b. Direct-Treatment Methods: Solidification—Lime-Based Methods

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	handling of solidifying material can result in release of fugitive dusts	none; unavoidable
	drying process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan

TABLE 7.4c. Direct-Treatment Methods: Solidification—Thermoplastic-Based Method

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	drying process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	process uses heat energy for solidification	none; unavoidable aspect of this technology

TABLE 7.4d. Direct-Treatment Methods: Solidification—Organic-Polymer-Based Methods

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	weep waters evolved during curing process can contaminate ground water	contain weep waters and handle as contaminated matter
Surface-Water Quality	weep waters evolved during curing process can contaminate receiving waters	see ground-water quality above
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan

TABLE 7.4e. Direct-Treatment Methods: Solidification—Self-Cementing Methods

Affected Area	Effect	Mitigation Measure
Air Quality	handling of solidifying material can result in release of fugitive dusts	none; unavoidable
	drying process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	self-cementing process requires significant energy input	none; unavoidable aspect of technology

TABLE 7.4f. Direct-Treatment Methods: Solidification—Glassification Methods

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	drying process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	glassification process consumes significant amount of energy	none; unavoidable aspect of technology

TABLE 7.5a. Direct-Treatment Methods: Encapsulation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	handling process may release hazardous vapors or fugitive dusts	none; unavoidable
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	fusing of containers consumes significant amount of energy	none; unavoidable aspect of this technology

TABLE 7.6a. Direct-Treatment Methods: In Situ Treatment—Solution Mining

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	elutriate can contaminate ground water	design carefully; establish procedures for monitoring; consider possibility of abnormal weather conditions; treat ground-water if contamination occurs (see EPA 1982, Section 4)
Air Quality	vaporizing elutriate can reduce air quality	none; unavoidable aspect of this technology
	uncontrolled reaction between elutriate and waste matter can result in release of hazardous matter	none; unavoidable aspect of this technology
Biota	some elutriate components toxic to biota	none; unavoidable if those agents are used

TABLE 7.6b. Direct-Treatment Methods: In Situ Treatment—Neutralization/Detoxification

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	reaction can produce leachate that can contaminate ground water	careful design; establish procedures for monitoring; if ground-water contamination occurs, ground-water treatment may be required (see EPA 1982, Section 4)
	immobilized material may subsequently be mobilized by change in soil chemistry and contaminate ground water	monitor; if contamination occurs, ground-water treatment may be required (see EPA 1982, Section 4)
Air Quality	evaporating reagents can reduce air quality	none; unavoidable aspect of this technology
	uncontrolled reaction between reagent and waste matter can result in release of hazardous matter	none; unavoidable aspect of this technology
Biota	some reagents toxic to biota	none; unavoidable if those agents are used

TABLE 7.6c. Direct-Treatment Methods: In Situ Treatment—Microbial Degradation

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	waste matter can leach before degradation is complete and contaminate ground water	design carefully; establish procedures for monitoring; consider possibility of abnormal weather conditions; if ground-water contamination occurs, ground-water treatment may be required (see EPA 1982, Section 4)
	nutrients added to assist microbial growth may contaminate ground water	monitor; if contamination occurs, ground-water treatment may be required (see EPA 1982, Section 4)

TABLE 7.7a. Direct-Treatment Methods: Other Direct Treatment Methods—Molten-Salt Process

Affected Area	Effect	Mitigation Measure
Air Quality	handling process may release hazardous vapors or fugitive dusts	none; unavoidable aspect of this technology
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	molten-salt process consumes significant amount of energy	none; unavoidable aspect of this technology

TABLE 7.7b. Direct-Treatment Methods: Other Direct Treatment Methods—Plasma-Reduction Process

Affected Area	Effect	Mitigation Measure
Air Quality	handling process may release hazardous vapors or fugitive dusts	none; unavoidable aspect of this technology
Soils/Geology	spills of contaminated matter may contaminate soils	spills should be expected and spill cleanup incorporated in operating plan
Resource Commitment	plasma-reduction process consumes significant amount of electrical energy	none; unavoidable aspect of this technology

8.0 CONTAMINATED WATER AND SEWER LINES

Contamination of sewer and water lines can occur as a result of infiltration of contaminated ground water or as the result of illegal dumping. When contamination of sewer or water lines occurs, three basic remedial options are available: in-place cleaning, in-place leak detection and repair, or removal and replacement.

8.1 IN SITU CLEANING

Contaminants may be removed from water or sewer lines in situ by mechanical and hydraulic scouring, bucket dredging and suction cleaning, or chemical treatment. The possible effects of these activities are summarized in Table 8.1 and described in the good engineering practice table, Table 8.1a, at the end of this section.

For each of these methods, the potential exists for hazardous material to be released to the atmosphere or spilled during the handling process. The potential for atmospheric releases is quite small, but spills can be expected, and should be planned for, and remedied by cleaning up and treating the spilled matter as contaminated soil.

Additionally, a certain amount of noise and traffic disruption will occur during the cleaning process. These effects are integral to such an operation and can only be partially mitigated by operating during normal daylight hours and avoiding, to the extent possible, traffic disruptions during rush hours.

TABLE 8.1. Contaminated Water and Sewer Lines: In Situ Cleaning

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	—	—	● NSI ○ HSI ● NSR	● HPR —	—	● NSI —	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

○ = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

8.2 LEAK DETECTION AND REPAIRS

Detecting and repairing leaks involves sewer inspection, poisoning of intruding roots with copper sulfate or other appropriate herbicide, and grouting or relining and sleeving. The possible effects of leak detection and repair are summarized in Table 8.2 and described in the good engineering practice table, Table 8.2a, at the end of this section.

During leak detection and repair, the potential exists for material to be released to the atmosphere or spilled during the operation. The potential for atmospheric releases is quite small, but spills can be expected, and should be planned for, and remedied by cleaning up and treating the spilled matter as contaminated soil.

TABLE 8.2. Contaminated Water and Sewer Lines: Leak Detection and Repairs

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● NSR	—	● NSI	● HPR	—	● NSI	—
—	—	—	—	○ HSI	—	—	—	—
—	—	—	—	● NSR	—	—	—	—

● = Highly Probable

○ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Additionally, a certain amount of noise and traffic disruption will occur during the leak detection and repair process. These effects are integral to such an operation and can only be partially mitigated by operating during normal daylight hours and avoiding, to the extent possible, traffic disruptions during rush hours.

An additional effect can occur if the root poison used enters the sewage treatment system. This can cause an upset at the sewage treatment facility, resulting in noxious emissions and transitory release of less-than-fully-treated sewage to receiving waters.

8.3 REMOVE AND REPLACE

Removing contaminated sewer or water lines and replacing these with new lines or moving the lines are major construction activities. These activities may involve excavation into contaminated media. The possible effects of the remove-and-replace option are summarized in Table 8.3 and described in the good engineering practice table, Table 8.3a, at the end of this section.

TABLE 8.3. Contaminated Water and Sewer Lines: Remove and Replace

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
○ HPR	—	● HPR	—	● HPR	● HPR	● HPR	● HPR	—
—	—	● NSR	—	● NSR	—	● NSR	● NSR	—

● = Highly Probable

○ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Removal of incompletely drained sewer pipes can readily result in the contamination of adjacent soils (if not already contaminated). In an extreme case, this might result in ground-water contamination. This effect can be prevented by in situ cleaning before the removal operation (see Section 8.2 of EPA 1982).

The major construction activities associated with removal and replacement of contaminated sewer or water lines will involve disruption of the surface. If the line passes under sensitive areas such as roads, parks, forests, wetlands, or critical habitat, removal and replacement will disrupt surface growth, surface structures, and interfere with human and wildlife activities for the period of the activity. Restoration of vegetation to the original state may be costly and may take an extended period. Disruption of human activity will evoke public resistance and will probably require the commitment to restore surface conditions to the original condition. Wildlife patterns could be disrupted permanently. Disruption of the surface is concomitant to the remove-and-replace option and the appropriate restoration activities are the only mitigation.

The construction activities can result in contaminated and uncontaminated fugitive dusts being released and transported off site where these can contaminate soils and form a hazard to human health and safety and biota. Fugitive dust can be controlled by water spraying and other control techniques (see Addendum 1).

The construction activities can also result in contaminated or uncontaminated sediments running off site and onto neighboring lands or into receiving waters where they can affect biota and human health and safety. This effect can be prevented by the use of surface-water diversion and collection controls (EPA 1982).

Construction activities also will result in noise and disruptions of traffic. These effects can be mitigated in part by operating only during normal daylight hours.

TABLE 8.1a. Contaminated Water and Sewer Lines: In Situ Cleaning

Affected Area	Effect	Mitigation Measure
Air Quality	atmospheric release of hazardous matter is possible during handling	none; unavoidable but improbable
Soils/Geology	spills of material removed from the lines can contaminate soils	plan for spills; clean up and treat spilled matter as contaminated soil
Public Health or Safety	noise and traffic disruption can be expected	schedule operations to reduce effects of noise and reduce traffic disruption

TABLE 8.2a. Contaminated Water and Sewer Lines: Leak Detection and Repairs

Affected Area	Effect	Mitigation Measure
Air Quality	atmospheric release of hazardous matter is possible during handling	none; unavoidable but improbable
Surface-Water Quality	root poisons may cause upset at sewage treatment facility resulting in release of less-than-fully-treated sewage	consider effect of root poison on sewage treatment; may be unavoidable
Soils/Geology	spills of material removed from the lines can contaminate soils	plan for spills; clean up and treat spilled matter as contaminated soil
Public Health or Safety	noise and traffic disruption can be expected	schedule operations to reduce effects of noise and reduce traffic disruption

TABLE 8.3a. Contaminated Water and Sewer Lines: Remove and Replace

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	spills from incompletely drained sewer lines can contaminate ground waters	in situ cleaning before removal (see EPA 1982, Section 8.2)
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	runoff can carry contaminated soils as sediment to receiving waters	see ground-water quality above
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	excavation to sewer line can bring contaminated soils to surface where these can become contaminated fugitive dusts	control contaminated fugitive dust (see Addendum 1)
	removal of incompletely drained sewer line can contaminate surface soils, which can become contaminated fugitive dusts	see ground-water quality above
	construction activities will result in noise	none; unavoidable; schedule operations to reduce the effect
Soils/Geology	spills from incompletely drained sewer lines can contaminate soils	see ground-water quality above
Biota	fugitive dust (contaminated or uncontaminated) from excavation can affect nearby biota	prevention is key (see air quality above); remediation is difficult
	sediment (contaminated or uncontaminated) from excavation can affect aquatic biota	see surface-water quality above
	biota will be disturbed in area of construction activity	none; unavoidable but temporary if area revegetated; wildlife patterns may be permanently affected
Public Health or Safety	contaminated fugitive dust or contaminated sediment from excavation activities can carry hazardous material off site	see air quality and surface-water quality above
	excavation of buried lines may result in traffic disruption	schedule operations to minimize effect

9.0 CONTAMINATED SEDIMENTS

Sediments in or adjacent to surface water may become contaminated as a result of migration from an uncontrolled hazardous-waste site. This section describes the effects of removing these sediments (by mechanical dredging or low-turbidity hydraulic dredging), managing dredge spoils, and revegetating wetlands from which the sediment may have been removed. It should be noted that the choice of mechanical dredging or low-turbidity hydraulic dredging is specific to the site. As discussed in EPA 1982, mechanical dredging is applicable under a limited set of circumstances; under other circumstances, hydraulic dredging is required.

9.1 MECHANICAL DREDGING

Mechanical dredging involves diversion of the stream (or other waterbody) around the contaminated area through the use of coffer dams and diversion conduits, together with physically removing the contaminated material using a backhoe, clamshell, dragline, front loader, or similar excavation equipment. The possible environmental effects associated with mechanical dredging are summarized in Table 9.1 and described in the good engineering practice table, Table 9.1a, at the end of this section.

This operation involves construction activities in and adjacent to the waterway outside of the contaminated area. The benthic and riparian zones will be disturbed in the areas where construction activities occur, so the biota inhabiting these zones will be disturbed and could be adversely affected. Disturbing soils and sediments in the uncontaminated area will lead to turbidity in the waterway. These effects are inherent to the construction activities and cannot be avoided; however, they are also brief, extending only over the construction period.

Construction of a coffer dam involving a pile driver, or similar activities, will produce noise. This noise is also unavoidable, but can be mitigated in part by operating only during normal working hours.

It is probable that the site from which the contaminated sediments will be removed will not be accessible by road. Construction of access roads will disturb the biota and may require filling in some wet- and/or low-land areas. If these road accesses are removed and the areas revegetated (see Section 9.4 of EPA 1982) when cleanup activities are completed, the negative effects on the area and inhabiting biota are temporary and confined only to the cleanup period.

TABLE 9.1. Contaminated Sediments: Mechanical Dredging

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● NSI	—	● NSI	● HPR	—	● NSI	—
—	—	○ HSI	—	—	—	● NSI	—	—
—	—	—	—	—	—	○ HPI	—	—

● = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

It may not be desirable or possible to divert the waterway from the contaminated area; alternatively, it may be possible to conduct the mechanical-dredging operation in-stream. During in-stream mechanical-dredging operations, contaminated sediments would be resuspended. This might cause a greater hazard to man and biota than if the sediment were allowed to remain in place. Thus, if the dredging operation is conducted in-stream, silt curtains (used to contain the majority of the resuspended silt) would be an integral part of the operation (as described in EPA 1982). However, some sediment would escape the silt curtains and would present a possible hazard to man and biota. Also, during in-stream mechanical dredging, sorbed contaminants will desorb into the water and be carried off in solution. This contamination of the surface water by dissolved contaminants is transitory, confined only to the period of cleanup, and is unavoidable with in-stream dredging.

In removing the contaminated sediments, spills of sediments and dewatering liquids are to be expected. These spills will contaminate soils within the site area and should be cleaned up at the close of site activities.

To remove contaminated sediments, a large volume of material will be moved. This implies a great deal of traffic related to hauling, and hauling traffic presents a noise and safety hazard to the public. These adverse effects are unavoidable, but can be mitigated in part by confining traffic to normal daylight hours and avoiding, to the extent possible, populated areas.

9.2 LOW-TURBIDITY HYDRAULIC DREDGING

Low-turbidity hydraulic dredging involves pumping the sediments from the bottom into barge containment. Because all of the material removed is contained during the operation, this method reduces the effects caused by operations. The possible effects that may occur with low-turbidity hydraulic dredging are summarized in Table 9.2 and described in the good engineering practice table, Table 9.2a, at the end of this section.

TABLE 9.2. Contaminated Sediments: Low-Turbidity Hydraulic Dredging

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● HSI	—	—	—	● NSI	○ HSI	—
—	—	● NSI	—	—	—	○ HSI	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

○ = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Dredging will, however, disturb the habitat of benthic biota. In addition, sorbed contaminants can desorb into the water and be carried off in a dissolved state. Finally, low-turbidity dredging is not 'no-turbidity' dredging. Some sediments, both contaminated and uncontaminated, will be suspended. Depending on site-specific conditions, the resuspended sediment that escapes the silt curtains may present a hazard to man and biota. All of these effects are unavoidable products of the low-turbidity hydraulic-dredging operation, but are confined to the period of operation and short times thereafter.

9.3 DREDGE-SPOIL MANAGEMENT

Dredge-spoil management consists of activities involved with handling the dredged material after it has been removed. These activities include the dewatering and transport, storage and disposal, and any separation or treatment activities that might be conducted to reduce the volume of material to be disposed of in a secure site. The possible effects that may occur during dredge-spoil management are summarized in Table 9.3 and described in the good engineering practice tables, Tables 9.3a-c, at the end of this section.

Dewatering and transport involve reducing the amount of entrained water in the sediment and transporting the contaminated matter to the ultimate disposal site. Off waters can contain contaminated material in suspension or in solution. If the off waters end up on the soil or in surface waters, the soil or surface water will be contaminated (for instance, if, as described in EPA 1982, a clamshell operator dewateres the solids by holding these over land or over water before loading onto the truck). This effect can be mitigated by dedicating an area to off-water containment and treating the waters as contaminated material. In handling contaminated sediments, spills of the sediments are nearly inevitable. These spills will contaminate the soils where they occur. This effect is mitigated by recognizing the potential for spills and cleaning these up at the end of site activities. Finally, the transport operation includes trucking the contaminated sediments off site to a point of ultimate disposal. This involves the fugitive dust, noise, and safety hazards associated with trucking along the haul route. The noise and

TABLE 9.3. Contaminated Sediments: Dredge-Spoil Management

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Dewatering and Transport	—	—	● HSR	—	● NSI	● HPR	—	● NSI	—
Storage and Disposal	● HSR	—	● HSR	—	—	—	—	—	● NPI
Separation	● NSR	—	● HSR	—	○ NSI	—	—	—	—
	—	—	● NSR	—	—	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

safety effects are irremediable, but may be mitigated, in part, by conducting trucking activities only during normal daylight working hours and avoiding, to the extent possible, populated areas. Fugitive dusts caused by truck hauling are inevitable; release of hazardous matter can be prevented by containing loads.

Storage and disposal involves temporary or permanent holding of dredge spoils after their removal from the river bottom. Waters emanating from these spoils will be contaminated and can, in turn, contaminate ground and/or surface waters. If the spoils are placed for ultimate disposal, contaminants on the sediments may remobilize and contaminate ground or surface waters. Whether the spoils are held for storage or for permanent disposal, runoff waters should be collected, monitored, and treated if contaminated. Because chemical conditions may change after the material has been removed from the river, monitoring and the option for treatment of runoff waters should continue for an extended period of time. There is an implied commitment to monitor and treat, if necessary, runoff waters for the period that the spoils remain hazardous.

Physical or chemical processing of contaminated sediments to reduce the amount of material to be disposed of in a secure site may be deemed to be cost effective. Physical separation may involve screening, flotation, and other methods (EPA 1982). Chemical separation may involve the use of solvents to remove the contaminants. Physical separation using water as a separation medium may result in contaminated waters if the contaminants dissolve. Chemical treatment can result in emissions of reagent or solvent material, and spills of contaminated water or solvents can contaminate surface waters or ground waters. The effects of such spills can be mitigated by recognizing their potential and planning for their clean up as part of site restoration. Solvent releases to surface or ground waters or releases of waters used in physical separation should be guarded against and should be contained and cleaned up at the time of the release.

9.4 REVEGETATION

When the sediments have been removed from wetland environments, it may be deemed necessary to replace the dredged material and revegetate the area to provide habitat and reduce suspended solids in the water by stabilizing the soils. The potential effects associated with revegetation are summarized in Table 9.4 and described in the good engineering practice table, Table 9.4a, at the end of this section.

TABLE 9.4. Contaminated Sediments: Revegetation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● NSI	—	—	—	● NPR	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

⊙ = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

The revegetation process may involve bringing in additional soils, introducing or seeding with appropriate vegetation, and applying agricultural chemicals (fertilizers and herbicides). Inevitably, bringing in additional soils, fertilizing, and applying herbicides will introduce suspended solids, nutrients, and herbicides into the water. These effects are integral to the process, but will disappear when the revegetation is complete. Bringing in outside soils presents the possibility for introducing species that do not fit into the local ecosystem; this potential effect is mitigable in part by selecting soils for fill from similar ecosystems.

TABLE 9.1a. Contaminated Sediments: Mechanical Dredging

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from disturbed soils can carry sediment to receiving waters	none; unavoidable, but temporary if area revegetated
	use of in-stream dredging will result in release of contaminated suspended sediment and dissolved contaminants	silt curtains will minimize but not eliminate release of contaminated sediment; release of dissolved contaminants unavoidable but temporary aspect of in-stream dredging
Air Quality	haulage activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1); secure loads to prevent releases from trucks
	haulage activities will result in noise along haul route	schedule hauling to minimize effect
	use of pile driver to build coffer dam will cause noise	none; unavoidable; schedule operation to minimize effect
Soils/Geology	spills of sediments and dewatering liquids will contaminate handling area	use dedicated handling area and clean up at end of site activity
Biota	biota will be disturbed in area of construction activity	none; unavoidable, but temporary if revegetated
	road construction to site, if required, may affect wetlands and biota	none; unavoidable, but temporary if accesses are removed and area revegetated
	contaminated suspended sediment or dissolved contaminant may pose risk to biota	none; unavoidable, but short-term, aspect of this technology
Public Health or Safety	contaminated suspended sediment or dissolved contaminant may pose public health risk	unavoidable, but short-term, aspect of this technology
	haulage activities can present safety hazard along haul route	plan route and scheduling to minimize hazard

TABLE 9.2a. Contaminated Sediments: Low-Turbidity Hydraulic Dredging

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	dredging will result in release of small amount of contaminated suspended sediment and dissolved contaminants	silt curtains will minimize, but not eliminate release of contaminated sediment; release of dissolved contaminants unavoidable, but temporary, aspect of in-stream dredging
Biota	biota will be disturbed in area of dredging activity	none; unavoidable aspect of this technology
	contaminated suspended sediment or dissolved contaminant may affect biota	none; unavoidable, but short-term, aspect of this technology
Public Health or Safety	contaminated suspended sediment or dissolved contaminant may pose public health risk	none; unavoidable, but short-term, aspect of this technology

TABLE 9.3a. Contaminated Sediments:Dredge-Spoil Management—Dewatering and Transport

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Surface-Water Quality	dredge-spoil off waters may contain dissolved or suspended contaminated matter, which can contaminate surface waters	contain off waters and treat as contaminated material
Air Quality	haulage activities can result in release of fugitive dusts along route	secure loads to prevent releases from trucks
	haulage activities will result in noise along haul route	schedule hauling to minimize effect
Soils/Geology	spills of dewatering liquids will contaminate handling area	use dedicated handling area and clean up at end of site activity
Public Health or Safety	haulage activities can present safety hazard along haul route	plan route and scheduling to avoid hazard

TABLE 9.3b. Contaminated Sediments:Dredge-Spoil Management—Storage and Disposal

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	dredge-spoil runoff may contain dissolved contaminants, which can contaminate ground water	contain runoff, monitor, and treat if required
Surface-Water Quality	dredge-spoil runoff may contain dissolved or suspended contaminated matter which can contaminate surface waters	contain runoff, monitor, and treat if required
Resource Commitment	storage or disposal of dredge spoils implies commitment to monitor and treat runoff waters, if necessary, over the period that the spoils remain hazardous	none; unavoidable effect of this option

TABLE 9.3c. Contaminated Sediments:Dredge-Spoil Management—Separation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	dredge-spoil processing waters may contain dissolved contaminants which can contaminate ground water	contain process waters, monitor, and treat as required
	spills of processing reagents may contaminate ground water	plan for spills; clean up at time of spill
	separation agents can reduce air quality	none; unavoidable effect of this option
Surface-Water Quality	dredge-spoil process waters may contain dissolved or suspended contaminated matter, which can contaminate surface waters	contain process water and treat as contaminated material
	spills of processing reagents may contaminate surface waters	plan for spills; clean up at time of spill

TABLE 9.4a. Contaminated Sediments: Revegetation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Surface-Water Quality	revegetating wetlands by bringing in soil and fertilizing, and applying herbicides will introduce suspended solids, nutrients, and herbicides into surface waters	none; irremediable, but temporary aspect of this action
Biota	use of outside soil can introduce new and inappropriate species	use soil from similar ecosystems

10.0 REFERENCES

Beedlow, P. A. 1984. *Designing Vegetation Covers for Long-Term Stabilization of Uranium Mill Tailings*. NUREG/CR-3674 (PNL-4986), Nuclear Regulatory Commission, Washington, D.C.

EPA. 1982. *Handbook for Remedial Action at Waste Disposal Sites*. EPA-625/6-82-006, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio.

Shafer, J. M., P. L. Oberlander and R. L. Skaggs. 1984. *Mitigation Techniques and Analysis of Generic Site Conditions for Ground-Water Contamination Associated with Severe Accidents*. NUREG/CR-3681 (PNL-5072), Nuclear Regulatory Commission, Washington, D.C.

APPENDIX A

MONITORING SYSTEMS

Monitoring systems provide information on the effectiveness of the remedial action and provide early warning of breakdown of the remedy. These systems monitor ground-water, surface-water, and atmospheric releases. The potential effects of ground-water monitoring are summarized in Table A.1 and described in the good engineering practice table, Table A.1a, at the end of this section.

A.1 GROUND-WATER MONITORING

Ground-water monitoring involves installing wells into one or more aquifers and a continuing sampling program. The construction of the well presents the major potential for negative effects. Well cuttings and waters withdrawn during completion and sampling are very likely contaminated. If cuttings are allowed to fall where they may, additional soils may be contaminated. If water pumped during well completion is discharged to the surface, soil and surface-water contamination may result. These effects can be remedied by handling all material removed from the ground as contaminated matter to be disposed of properly.

Also, if several aquifers are being monitored, the well can potentially cause cross-aquifer contamination. This can be prevented by proper grouting and completion of the well (EPA 1982).

Drilling operations are noisy and may be a source of complaint. This can be mitigated in part by operating the drill rig only during normal daylight working hours.

The sampling program will disturb local biota during those periods when people and equipment are in the area. This is a temporary, but irremediable, aspect of the sampling program. If breeding habitat for sensitive species are nearby, disturbance can be mitigated by appropriate timing of sampling activities.

TABLE A.1. Monitoring Systems

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
Ground-Water Monitoring	● HPR	—	● HPR	—	● NSI	● HPR	● NSI	—	—
Surface-Water Monitoring	—	—	—	—	—	—	—	—	—
Gas Monitoring	—	—	—	—	—	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

A.2 SURFACE-WATER MONITORING

No significant effects are projected.

A.3 GAS MONITORING

No significant effects are projected.

REFERENCE

EPA. 1982. *Ground-Water Monitoring Guidance for Owners and Operators of Interim Status Facilities: Instructions for Complying with 40 CFR Part 265, Subpart F*. U. S. Environmental Protection Agency, Washington, D. C.

TABLE A.1a. Monitoring Systems: Ground-Water Monitoring

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	cross-aquifer contamination can result from multiple aquifer wells	establish and enforce procedures for well logging, grouting, and completion
Surface-Water Quality	water pumped during well completion can contaminate receiving waters	treat development waters as contaminated matter
Air Quality	drilling will produce noise	schedule drilling operations to reduce effect
Soils/Geology	drill cuttings or development waters may contaminate soil	treat all materials removed from the ground as contaminated matter
Biota	sampling activities will disrupt wildlife	none; unavoidable; if sensitive, schedule sampling to reduce effect

APPENDIX B

WASTE-WATER TREATMENT MODULES

Leachate may be treated using industrial waste-water treatment methods. The potential effects of these various treatment methods are described below. Note that these methods are not necessarily alternatives to each other. Instead, several may be used in concert to make up a treatment strategy alternative.

B.1 FLOW EQUALIZATION

Flow equalization basins act to dampen flow and concentration fluctuations in the treatment stream. Potential effects of this treatment option are summarized in Table B.1 and described in the good engineering practice table, Table B.1a, at the end of this section.

If the flow equalization basin is open to the atmosphere, hazardous materials may evaporate and degrade air quality. This effect may be remedied by covering the basin.

Construction of the equalization basin may result in construction-related effects. These effects include the emission of fugitive dusts, which can be reduced by water spray and other control means (see Addendum 1). Construction activities will also disturb soils; overland flow can then transport these disturbed soils as suspended solids to receiving waters. This effect can be mitigated by using surface-water diversion and collection controls (see Section 3.4 of EPA 1982) while the basin is being constructed and revegetating (see Section 3.3 of EPA 1982) after construction activities are completed.

TABLE B.1. Waste-Water Treatment: Flow Equalization

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	●NSR	—	●NSR	—	●NSR	—	—
—	—	—	—	●HSR	—	—	—	—

● = Highly Probable

● = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

B.2 PRECIPITATION, FLOCCULATION, AND SEDIMENTATION

Precipitation, flocculation, and sedimentation are waste-water treatment processes that are used widely to treat industrial waste waters containing particulates and/or heavy metals. Each of these processes produces by-products that must be properly disposed of. Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse effects to the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site. Potential effects of this treatment option are summarized in Table B.2 and described in the good engineering practice table, Table B.2a, at the end of this section.

TABLE B.2. Waste-Water Treatment: Precipitation, Flocculation and Sedimentation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● NSR ● HPR	—	● NSR ● HPR	● HPR	● NSR ● HPR	● HPR —	—

● = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

Each of the processes uses reagents; spills of these reagents and/or runoff from reagent storage may contaminate surface waters. Spills of the reagents, although not inevitable, are probable, so cleanup and disposal plans should be part of the operating plan. Reagent storage areas should be designed so that runoff from these is collected and diverted to the treatment facility.

Construction of the precipitation, flocculation, and sedimentation facilities may result in construction-related effects. These effects include the emission of fugitive dusts, which can be reduced by water spraying and other control techniques (see Addendum 1). Construction activities will also disturb soils, which can carry suspended solids to receiving waters by overland flow. This effect can be mitigated by using surface-water diversion and collection controls (see Section 3.4 of EPA 1982) while the basin is being constructed and revegetating (see Section 3.3 of EPA 1982) after construction activities are completed. If not prevented, these fugitive dusts and sediment releases can affect resident biota.

B.3 BIOTREATMENT

Most organic chemicals are biodegradable and a large number of biotreatment options are available. All of these produce a by-product that must be disposed of properly, although the by-product will probably be much less hazardous than the original material. Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse effects on the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site. Potential effects of this treatment option are summarized in Table B.3 and described in the good engineering practice table, Table B.3a, at the end of this section.

Construction of biotreatment facilities may cause adverse effects such as the emission of fugitive dusts. Construction activities will also disturb soils, which can carry suspended solids to receiving waters by overland flow. This effect can be mitigated by using surface-water diversion and collection controls (see Section 3.4 of EPA 1982) while the basin is being constructed and revegetating (see Section 3.3 of EPA 1982) after construction activities are completed. Fugitive dusts can be reduced by water spraying and other control techniques (see Addendum 1). If not prevented, these fugitive dusts and sediment releases can affect resident biota.

TABLE B.3. Waste-Water Treatment: Biotreatment

	Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
	Quality	Movement/ Quantity	Quality	Movement/ Quantity					
All Biotreatment Methods	⊙ HPR — —	— — —	⊙ NSR ⊙ HPR —	— — —	⊙ HPR ● NSR ⊙ NSI	⊙ HPR — —	⊙ HPR — —	⊙ HPR — —	⊙ NSI — —
Activated Sludge	—	—	—	—	—	—	—	—	● NSI
Trickling Filters	—	—	—	—	—	—	—	—	● NSI
Rotating Biological Disks	—	—	—	—	—	—	—	—	● NSI
Bioseeding	—	—	—	—	—	—	—	⊙ NSR	—
Anaerobic, Aerobic, and Facultative Lagoons	—	—	—	—	—	—	—	—	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

⊙ = Probable

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○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

Biotreatment processes may release noxious or offensive odors that may degrade air quality. This problem is common to the processes and is not specifically mitigable. Activated sludge, trickling filter, and rotating biological disk processes require a commitment of energy for pumping or for rotating the disks. This resource commitment is integral to these biotreatment processes and is not mitigable.

Bioseeding, that is the introduction of specifically adapted microorganisms to any of the biotreatment options, can potentially be perceived by the public as a health and safety risk associated with exotic microorganisms. Although this effect is perceptual rather than actual, it could affect the operation of the treatment facility if public opposition is aroused. This can be avoided by educating the public.

B.4 CARBON SORPTION

Carbon sorption can be used in a treatment mode for dilute leachate or in a polishing mode. Aside from disposal of spent carbon or waste material obtained during regeneration of the carbon, no significant effects are associated with the use of carbon sorption as a treatment option. Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse affects on the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site. Table B.4 has no entries except those related to by-product disposal. Table B.4a, at the end of this section describes the good engineering practices for by-product disposal.

TABLE B.4. Waste-Water Treatment: Carbon Sorption

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● HPR	—	● HPR	● HPR	● HPR	● HPR	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

B.5 ION EXCHANGE

Ion-exchange resins can be used, in the same way as carbon, to sorb specific hazardous materials in a polishing mode or a direct treatment mode for very dilute leachates. Again, no significant adverse effects other than those related to disposal of resins and by-products are associated with this process. Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse effects to the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site. Table B.5 has no entries except those related to by-product disposal and Table B.5a at the end of the section describes good engineering practices for by-product disposal.

TABLE B.5. Waste-Water Treatment: Ion Exchange

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● HPR	—	● HPR	—	● HPR	● HPR	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

B.6 LIQUID ION EXCHANGE

Liquid ion exchange involves selectively removing contaminants from the leachate by dissolution in an immiscible organic material. Potential effects of this treatment option are summarized in Table B.6 and described in the good engineering practice table, Table B.6a, at the end of this section.

The immiscible organic material is at least partially soluble in the aqueous stream, and releases of the solvent to the stream must either be tolerated or the stream must undergo further treatment to remove

TABLE B.6. Waste-Water Treatment: Liquid Ion Exchange

Ground-Water		Surface-Water		Air Quality	Soils/Geology	Biota	Public Health/Safety	Resource Commitments
Quality	Movement/Quantity	Quality	Movement/Quantity					
● HPR	—	● HPR	—	● HPR	● HPR	● HPR	● HPR	—
—	—	● NSR	—	—	—	—	● NSR	—

- = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)
- NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

traces of the solvent. In addition, spills of the solvent may contaminate surface waters if not contained. The solvents themselves can represent a health or safety hazard to personnel working at the site or to the public. Many of the solvents are flammable and some are toxic. If a fire or explosion occurs at the facility, the hazardous material could be spread over a greater area than was originally contaminated. Although this possibility is remote, it must be considered. Proper safety planning and precautions can reduce the probability of such accidents.

The ion-exchange process produces by-products which must be disposed of properly. Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse effects to the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site.

B.7 AMMONIA STRIPPING

Ammonia stripping is a process wherein ammonia in the waste stream is sparged with air. Potential effects of this treatment option are summarized in Table B.7 and described in the good engineering practice table, Table B.7a, at the end of this section.

TABLE B.7. Waste-Water Treatment: Ammonia Stripping

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	—	—	● NSR	—	—	—	—
—	—	—	—	● HSR	—	—	—	—

- = Highly Probable ○ = Probable ○ = Improbable
 N = Nuisance H = Hazardous — = No significant effects predicted
 S = Short-term (construction phase only) P = Persistent (beyond construction phase)
 R = Reversible (or mitigable) I = Irreversible (unmitigable)
- NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

If open to the atmosphere, this stripping process will release ammonia to the air, which may degrade air quality in the vicinity of the treatment site. If the air quality would be degraded significantly, the ammonia should be collected in a sorption unit. Hazardous volatile compounds may also be sparged with the ammonia. This effect is unavoidable with the use of this technology.

B.8 WET-AIR OXIDATION

No significant adverse effects other than those associated with improper disposal of by-products were found to be associated with wet-air oxidation. Table B.8 has no entries except those related to by-product disposal, and good engineering practices for by-product disposal are described in Table B.8a, at the end of this section.

Failure to dispose of these by-products properly can result in ground-water, surface-water, air, and soil contamination, which can result in adverse effects to the public and biota residing near the disposal site. Proper disposal means treating the by-products as hazardous matter and disposing of these in a RCRA-approved site.

TABLE B.8. Waste-Water Treatment: Wet-Air Oxidation

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
● HPR	—	● HPR	—	● HPR	● HPR	● HPR	● HPR	—
—	—	—	—	—	—	—	—	—

● = Highly Probable

○ = Probable

○ = Improbable

N = Nuisance

H = Hazardous

— = No significant effects predicted

S = Short-term (construction phase only)

P = Persistent (beyond construction phase)

R = Reversible (or mitigable)

I = Irreversible (unmitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

B.9 CHLORINATION

Chlorination is a process used in waste-water treatment to disinfect, to control odor, and to reduce biological oxygen demand. Potential effects of this treatment option are summarized in Table B.9 and described in the good engineering practice table, Table B.9a, at the end of this section.

Chlorination involves introducing gaseous chlorine into the waste-water stream. The presence of gaseous chlorine on site introduces the possibility of atmospheric releases of chlorine with attendant air-quality degradation and, in the case of a significant accident, a hazard to human health and safety. This effect is an irremediable, but improbable, component of the use of gaseous chlorine.

Chlorination can reduce the biological oxygen demand. However, depending on the chemical constituents in the waste stream, chlorination can turn relatively benign contaminants into more hazardous contaminants (for instance, chlorination can convert phenols into polychlorinated

TABLE B.9. Waste-Water Treatment: Chlorination

Ground-Water		Surface-Water		Air Quality	Soils/ Geology	Biota	Public Health/ Safety	Resource Commitments
Quality	Movement/ Quantity	Quality	Movement/ Quantity					
—	—	● HSI	—	● NSI	—	● NSR	● HSI	—

● = Highly Probable

N = Nuisance

S = Short-term (construction phase only)

R = Reversible (or mitigable)

NB: Multiple entries in a category indicate that several different types of effects are foreseen as possible.

● = Probable

H = Hazardous

○ = Improbable

— = No significant effects predicted

P = Persistent (beyond construction phase)

I = Irreversible (unmitigable)

phenols). Toxic contaminants may adversely affect human health and that of biota residing in the receiving streams. This effect is an integral and unmitigable aspect of the use of chlorination in waste-water treatment and should be considered when considering the chlorination option. Also, if the waste-water stream is released with free chlorine remaining in the stream, this chlorine will be toxic to biota in the receiving waters. This effect can be mitigated by the use of a dechlorination facility. The effects of chlorination of waste stream are discussed in numerous references; some of these are Bean, Riley, and Ryan (1978); Jolley et al. (1980); Jolley et al. (1983a); Jolley et al. (1983b); and Bean, Neitzel, and Thomas (1984).

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TABLE B.1a. Waste-Water Treatment Modules: Flow Equalization

Affected Area	Effect	Mitigation Measure
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	evaporation of hazardous matter may contaminate air	cover basin
Biota	fugitive dust from excavation can affect nearby biota	see air quality above
	sediment from excavation can affect aquatic biota	see surface-water quality above

TABLE B.2a. Waste-Water Treatment Modules: Precipitation, Flocculation, and Sedimentation

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	improper disposal of by-product matter can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	reagent spills can contaminate receiving waters	incorporate cleanup and disposal of reagent spills as part of operating plan
	runoff from reagent storage can contaminate receiving waters	collect runoff and divert to treatment area
	improper disposal of by-product matter can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	improper disposal of by-product matter can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of by-product matter can cause soil contamination	see surface-water quality above
Biota	fugitive dust from construction can affect nearby biota	see air quality above
	sediment from construction can affect aquatic biota	see surface-water quality above
	improper disposal of by-product matter can affect biota at disposal site	see surface-water quality above
Public Health or Safety	improper disposal of by-products can affect public health for persons near disposal site	see surface-water quality above

TABLE B.3a. Waste-Water Treatment Modules: Biotreatment

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	improper disposal of by-product matter can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	runoff from soils disturbed during construction activities can carry sediment to receiving waters	incorporate surface-water diversion and collection measures with revegetation as appropriate (see EPA 1982, Sections 3.3 and 3.4)
	improper disposal of by-product matter can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
Air Quality	construction activities can result in release of fugitive dusts	fugitive-dust control (see Addendum 1)
	biotreatment of some materials may release noxious or offensive odors	none; unavoidable effect of this technology
	improper disposal of by-product matter can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of by-product matter can cause soil contamination	see surface-water quality above
Biota	fugitive dust from construction can affect nearby biota	see air quality above
	sediment from construction can affect aquatic biota	see surface-water quality above
	improper disposal of by-product matter can affect biota at disposal site	see surface-water quality above
Public Health or Safety	improper disposal of by-products can affect public health of persons near disposal site	see surface-water quality above
	introduction of microorganisms can be perceived as health risk	education of public
	resource commitment	unavoidable; some processes require energy for operation; this is an integral part of these technologies

TABLE B.4a. Waste-Water Treatment Modules: Carbon Sorption

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	improper disposal of by-product matter can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	improper disposal of by-product matter can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
Air Quality	improper disposal of by-product matter can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of by-product matter can cause soil contamination	see surface-water quality above
Biota	improper disposal of by-product matter can affect biota at disposal site	see surface-water quality above
Public Health or Safety	improper disposal of by-products can affect public health of persons near disposal site	see surface-water quality above

TABLE B.5a. Waste-Water Treatment Modules: Ion Exchange

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	improper disposal of resins and by-product matter can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	improper disposal of resins and by-product matter can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
Air Quality	improper disposal of resins and by-product matter can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of resins and by-product matter can cause soil contamination	see surface-water quality above
Biota	improper disposal of resins and by-product matter can affect biota at disposal site	see surface-water quality above

TABLE B.6a. Waste-Water Treatment Modules: Liquid Ion Exchange

Affected Area	Effect	Mitigation Measure
Ground-Water Quality	improper disposal of by-product matter can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	improper disposal of by-product matter can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
	spills of ion-exchange liquid can contaminate receiving waters	plan for containing spills
	ion-exchange liquid in waste stream can contaminate receiving waters	none; unavoidable; treat waste stream to remove ion-exchange traces if needed
Air Quality	improper disposal of by-product matter can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of by-product matter can cause soil contamination	see surface-water quality above
Biota	improper disposal of by-product matter can affect biota at disposal site	see surface-water quality above
Public Health or Safety	personnel may be exposed to flammable or toxic vapors from ion-exchange liquid	proper safety planning and precautions
	fire or explosion of ion-exchange material could cause greater public exposure than current situation	proper safety planning and precautions
	improper disposal of by-product matter can affect public health near disposal site	see surface-water quality above

TABLE B.7a. Waste-Water Treatment Modules: Ammonia Stripping

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	released ammonia may degrade local air quality	collect ammonia in a sorption unit
	volatile hazardous materials may be sparged with the ammonia	none; unavoidable aspect

TABLE B.8a. Waste-Water Treatment Modules: Wet-Air Oxidation

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Ground-Water Quality	improper disposal of by-product matter (if any) can cause ground-water contamination	see surface-water quality below
Surface-Water Quality	improper disposal of by-product matter (if any) can contaminate surface waters	treat by-products as contaminated matter; dispose of in a RCRA-approved site
Air Quality	improper disposal of by-product matter (if any) can cause air contamination	see surface-water quality above
Soils/Geology	improper disposal of by-product matter (if any) can cause soil contamination	see surface-water quality above
Biota	improper disposal of by-product matter (if any) can affect biota at disposal site	see surface-water quality above
Public Health or Safety	improper disposal of by-products can affect public health for persons near disposal site	see surface-water quality above

TABLE B.9a. Waste-Water Treatment Modules: Chlorination

<u>Affected Area</u>	<u>Effect</u>	<u>Mitigation Measure</u>
Air Quality	leaks or accidental releases of chlorine can degrade local air quality	establish and enforce appropriate safety procedures
Biota	chlorination by-products may be toxic to biota	perform tests to determine chlorination products
	free chlorine in waste stream will be toxic to biota	use a dechlorination facility
Public Health or Safety	some chlorination by-products may be more toxic than those in waste stream	perform tests to determine chlorination products

ADDENDUM 1

FUGITIVE DUST

Fugitive-dust emissions are defined as any particulate emissions to the atmosphere that are not released through a stack, vent, duct, or other exhaust system designed to regulate the flow of the pollutants. Fugitive-dust emissions will occur as the result of wind erosion and/or construction activities (e.g., vehicular traffic, digging, blasting, etc.). The amount of material released to the atmosphere by wind erosion will depend on ambient wind speeds, atmospheric turbulence and stability, and the physical characteristics of the material itself (particle size, particle density, particle shape) (Chepil 1951; Bagnold 1954). Mechanically generated fugitive-dust emissions will depend on the type of construction activities (equipment, vehicle miles, etc.) and the physical properties of the surface material (Bohn et al. 1978). Potential amounts of fugitive-dust emissions and subsequent air concentrations can be estimated, if necessary, using established emission-factor guidelines and air-quality models (see e.g., Blackwood and Wachter 1978; Bohn et al. 1978; EPA 1979; EPA 1977). Such steps may be necessary if potential emission would result in a violation of the applicable total suspended particulate (TSP) and ambient air-quality standards. Likewise, it may be desirable or necessary to estimate fugitive-emission rates, air concentration, and deposition patterns if the material in question is deemed hazardous.

Several control strategies are available to regulate fugitive-dust emissions. These include treating the exposed surface to reduce dust emissions, or erecting wind barriers to reduce wind speeds and hence emission rates (Li et al. 1983). Treatment technologies include covering the surface with materials such as straw, bark, or rock; applying a water spray; and applying a chemical dust-suppressant compound. Covers are appropriate only if the material will not be further disturbed during construction activities. Water spray is only about 50% effective in reducing dust emissions and is a temporary measure only, requiring repeated application (PEDCo 1973). Numerous chemical treatments are available commercially and are very effective in controlling dust emissions (85% reduction and higher) (PEDCo 1973; Elmone and Hartley 1984). Their durability and effectiveness depends on the material being treated and subsequent construction activities which may erode the agents applied to the surface.

Wind barriers have been proven to regulate fugitive emissions effectively. They range from simple fencing (e.g., snow fencing) to more elaborate panels that are specifically designed to control fugitive emissions (Radkey and MacCready 1979; Li et al. 1983). Some commercial units are portable so they can be adjusted to particular wind directions or moved from site to site. Their effectiveness depends on their height and width, their 'porosity' to the ambient wind, and their positioning relative to the area to be protected. Wind barriers can also be constructed from materials removed during excavation and construction activities. If a sufficient amount of material must be temporarily removed and stored, it can be placed in a mound upwind of the areas likely to be subject to fugitive emissions. With proper placement and construction, such barriers can reduce wind speed below threshold levels at which wind erosion occurs. Davies (1980) reports on a physical modeling study of such a control strategy. Costs for fugitive-dust control are summarized in Table AD.1.

Construction-related dust emissions can be reduced by using a combination of the above mitigating measures, and regulating vehicle speeds (PEDCo 1973). Meteorological conditions conducive to intense dust emission and transport episodes can be monitored either on site or via a local weather office. Construction activities can then be controlled appropriately to reduce emissions during unfavorable atmospheric conditions.

TABLE AD.1 Fugitive-Dust Control Costs

	Water Spray ^(a)	Chemical Stabilizers ^(b)	Wind Barrier ^(c)
Unpaved Roads	\$3000/mile AOC ^{(d)(e)}	\$5000-12,000/mile AOC ^{(d)(e)}	Not applicable
Exposed Areas \$2-5/acre/day ^(f)	\$4-10/acre AOC ^{(d)(e)} \$300/hectare ^(g)	\$25-50/acre/appl. AOC ^{(d)(e)} \$2-13/meter ^(g)	\$35-350/acre AOC ^{(d)(e)}
Construction Site	\$2-5/acre/day ^(f)	\$25-50/acre/ application AOC ^{(d)(e)} \$2-13/meter ^(g)	\$35-50/acre AOC ^{(d)(e)}
Storage Pile for spray system \$10,000-11,000 est. for permanent system ^(e)	Installation cost \$0.01/sq ft/appl. ^(e)	\$150-400/acre ^{(f)(g)}	\$2-13/meter ^(g)

(a) Effectiveness of water spray depends on environmental factors and regularity of watering; costs will vary accordingly.

(b) Costs for chemical stabilization vary with compound used; research results indicate that less effective compounds require more frequent application, hence costs ranges may be narrower than reported.

(c) Limited data available on wind break costs; reported values are for tree liners and several commercial systems only.

(d) Annual operating costs; does not include initial costs for equipment purchase (e.g., spray trucks).

(e) Bohn et al. (1978).

(f) PEDCo (1973).

(g) Elmone and Hartley (1984).

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ADDENDUM 2

OTHER AIRBORNE EMISSIONS

Before implementing the remedial activities, the potential impacts resulting from release to the atmosphere of noxious or hazardous materials can be evaluated using established procedure. Gases, aerosols, or particles may be emitted as a result of routine operations or because of an accident (fire, explosion, etc.). The subsequent transport and diffusion of these materials will result in downwind concentrations, either on site or off site, that may adversely affect environmental quality or public welfare. After evaluating the potential sources of such emissions and their likelihood of occurrence, air-quality dispersion modeling techniques can be used to estimate the locations and magnitude of maximum impacts (Turner 1967; Hanna et al. 1982; Ramsdell and Athey 1981). Meteorological data for these studies can be provided through an on-site monitoring program or from historical observations collected at nearby weather stations. The results of these evaluations can be used to estimate maximum impacts and provide guidelines for construction-related activities to help minimize emissions, particularly during periods of unfavorable atmospheric conditions.

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